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GUIDELINES FOR ECONOMIC EVALUATION OF PUBLIC SECTOR WATER RESOURCE PROJECTS

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PREFACE

Water development plays an important role in the economy of states and regions. However, procedures for estimating the expected net worth of proposed projects have never been simple, and results have rarely been without controversy. This report presents some guidelines for the application of economic evaluation procedures in project analysis of public sector water development in North Dakota. A brief history of North Dakota water development and two case studies of North Dakota water projects are included in this report.

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Highlights

The changing character of public-sector water projects has brought about an increased interest in their evaluation. Comprehensive project planning involves several steps from initiation to ex-post analysis. One of the most significant steps from an efficiency and equity perspective is project analysis.

Several economic concepts need to be understood before analysis of a water project can be accomplished. This report discusses discounting and present value, public versus private values, externalities, benefit-cost analysis, and monetary quantification of project costs and benefits. Specific attention is given to recreation, irrigation, drainage, and flood control.

Analyses are discussed from the perspective of project users, local economies, and state economies. An economic efficiency model, a regional economic activity model, and a social well-being model are each introduced.

Two case studies--a multi-purpose dam and a drainage project--are presented to illustrate the concepts and models introduced.

The guidelines are written to assist state and local water managers and planners.

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INTRODUCTION

The purpose of this report is to present a procedural framework for socioeconomic evaluation of public sector water development in North Dakota. Water resources are a vital link in the livelihood of all American citizens. Water is relied on for farming, industry, community expansion, energy development, recreation, and tourism. As the demand for water in these alternative uses continues to increase, so does the need for comprehensive water resource planning. Public agencies charged with management of scarce natural resources must now take into account these multiple users, purposes, and objectives. Consequently, resource planners have had to broaden their perspective and examine a wider range of alternative plans.

Hoggan, Kimball, and Bagley (1981) suggest that due to the changing character of state-financed water projects, there is need to carefully reexamine development policies. Traditional projects have been small, single purpose, and relatively inexpensive. The direct benefits from these projects were usually evenly distributed within the local agricultural sector, and the indirect benefits helped to stabilize the social and economic structure of the rural communities. Emerging projects, however, tend to be more expensive, larger, and may impact many user groups. Therefore, there is a greater need to determine if emerging water development projects still generate significant public benefits to justify governmental participation. Equally important is the question of how the benefits are distributed to the state's populus.

Given the conflicting objectives of different user groups and the rapidly changing times, an optimal water development plan probably does not exist. However, resource decisions, in which public funds are invested to provide public and private benefits, should be made in some organized, consistent planning framework. By following a consistent and detailed planning outline, alternatives can be objectively defined, evaluated, and implemented.

Project planning is broad, involving the entire process from initiation to construction, although it is only one part in an overall water management program. Comprehensive planning of water resource systems requires a knowledge of economics, engineering, ecology, law, planning, and political science. This further illustrates the need for a planning outline which will aid in the objective evaluation and selection of complex alternatives.

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What follows is one possible, 12-step framework that can be used in resource decision making. It is not meant to be a rigid structure, but instead a flexible tool in the planning process.

Comprehensive Planning Framework

1. Initiate Project. Normally, water resource projects originate at the local level. The incentive for action may be a natural disaster, such as a flood, drought, or intolerable water quality conditions. Action may also be prompted by changing socioeconomic conditions. The problem or opportunity addressed is usually small in a geographical context, but may affect a number of users and varied interests.

2. Identify Objectives. Objectives should follow logically from Step 1 and express the specific problem or opportunities the proposed project is intended to address. Properly defined objectives will facilitate accomplishment of later planning steps but are not meant to capture the full range of effects actually produced.

3. Identify the Relevant Planning Area. Examples of planning areas include watersheds, water resource districts, statistical planning areas, public involvement regions, and political jurisdictions. This is an important step, since subsequent steps in the planning process are based on this delineation.

4. Select National Parameters. Examples of these parameters include the discount rate, wage rates, and output prices. This step is critical, since inappropriate parameter estimates used in project analyses can result in a potential misallocation of resources. Valid comparisons between projects require consistent parameters.

5. Identify the Problems or Restraints in the Planning Area. Issues and concerns which are important and significant should be identified. This identification may include social, economic, legal, technical, or environmental factors. An example would be the impact on adjacent political jurisdictions.

The process of problem identification usually requires information and inventory studies at the local level. Data are needed on natural resources, physical and social characteristics, economic activity, and institutions.

6. Develop Alternative Scenarios. All potentially feasible courses of action that might contribute to achieving the project objectives should be identified. Preliminary engineering feasibility studies will then be based on these alternatives. All scenarios need not complete project objectives. A "do nothing" approach or only partial solutions to the problem are examples of alternatives which should also be examined.

7. Analyze Project. This is a technical procedure involving a preliminary engineering feasibility study plus an evaluation of the economic, environmental, and social impacts associated with each alternative.

Project analysis is intended to provide information on the likely effectiveness and efficiency of a project in solving some problem (e.g., flooding) or achieving some goal (e.g., recreation development).

Project analysis is a critical step, because it brings economic efficiency criteria into the planning process. The goal is to determine which alternative or combination of alternatives is the most economically efficient means of meeting project objectives. The difficulty lies in that all significant impacts should be quantified and included in the analysis.

8. Select Best Alternative(s). Project analysis results are an integral part of this process. Politics, availability of funds, and social and environmental constraints are examples of additional factors that require consideration.

9. Obtain Public Feedback on Selected Scenarios. Although this step is being mentioned in the latter portion of the planning framework, public participation and input should be sought in all planning phases. Inclusion of public concerns and problems in the early stages will help avoid costly or embarrassing oversights and will contribute to effective, comprehensive planning.

10. After the best scenario has gone through the selection and public review process, the next step is to authorize and fund the project.

11. The next step is to construct the project, but this is not the end of the planning process. Ideally, if project parameters change substantially, the project should be re-evaluated. Even after construction has started, changing conditions may warrant re-evaluation and possible project changes or cancellation.

12. Ex Post Evaluation. Resource development entails many unknowns. After the project has been in existence, an *ex post* analysis will identify weak areas in the *ex ante* analysis (Step 7), thereby facilitating improved analysis of future projects.

Objectives

A major purpose of this report is to present some basic elements of public sector water development analysis in North Dakota. The intent is not to cover all aspects of water resource development, but rather to outline a planning and economic evaluation framework that can be used in resource decision-making.

The twelve-step planning framework described earlier is presented in Figure 1. Project analysis (Step 7) is only one step in the planning process; however, it has received the greatest attention and criticism in the past. The problem is not inherent in the methods of analysis but in the potential misuse and lack of adequate data needed to make project analysis an objective planning tool.

It has been argued that ". . . a benefit-cost ratio greater than unity attests more to the imagination of the planners than to the economic soundness of the investment" (Bromley et al. 1971). While this may

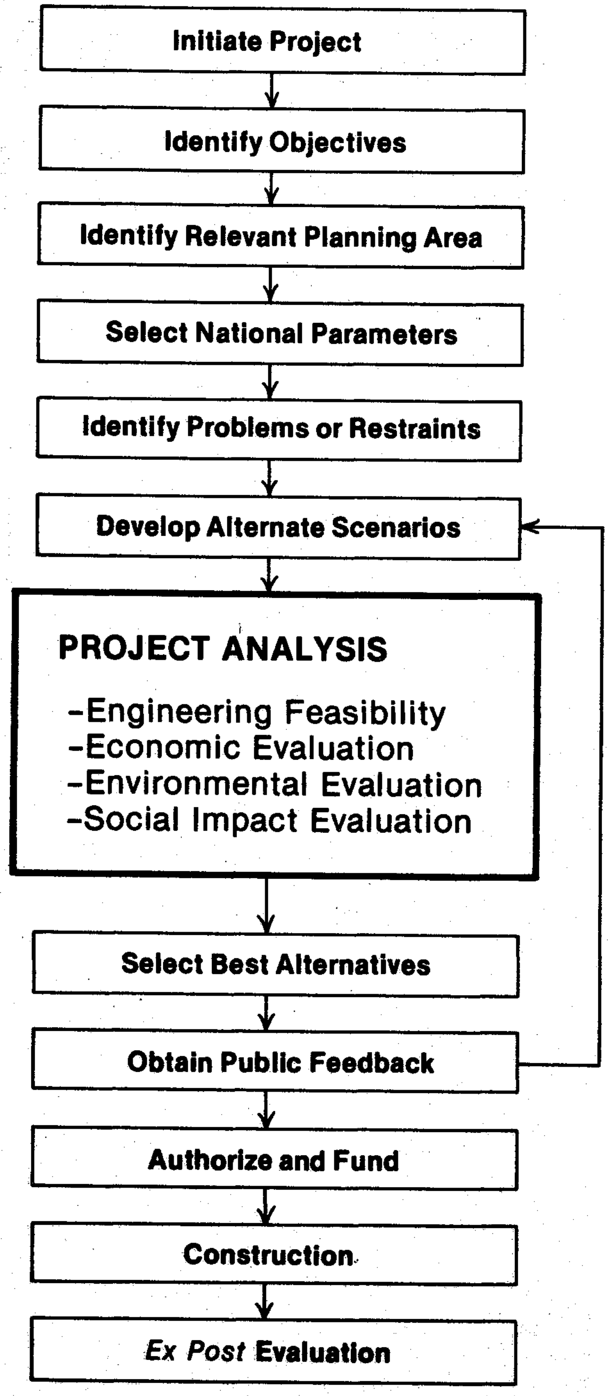


Figure 1. Planning Framework for Use in Public Sector Water Development

accurately describe many project analyses conducted in the past, it is not a sufficient argument for the complete dismissal of this planning step. Project analysis can provide a good screen for eliminating projects or alternatives that should not be seriously considered. The major emphasis in this report is to provide a guide for the application of economic evaluation procedures in water project analysis.

HISTORY OF NORTH DAKOTA WATER DEVELOPMENT

Water development has always played an important role in the economy of a region; North Dakota is no exception. Even before the United States was a nation, the waterways of North Dakota were dominating economic development in the West. Water development history is not only extensive but at times romantic, as was the fur trade, and at other times controversial, as is the Garrison Diversion project.

In the mid to late 1700s, the two great rivers of North Dakota, the Missouri and the Red, became focal points for trading in the West (Robinson 1966). Trappers brought furs from Canada by traveling upstream on the Red River. Trappers traveling the Missouri River brought furs from the entire Rocky Mountain Region. This era lasted until the mid 1800s when the trade finally ended.

Lewis and Clark, on their historic expedition, wintered on the banks of the Missouri and established Fort Mandan during their stay in North Dakota. From the 1830s until 1937 steamboats and packets plied their way up and down both the Missouri and Red Rivers. They provided freight, mail, and passenger service for the North Dakota settlers. Bismarck and Grand Forks were the main ports during this era.

Water development in North Dakota began with irrigation (Tweton and Jelloff 1976). In 1889, 445 acres were under irrigation and by 1899, 4,872 acres were being irrigated. In 1904, the state engineer was assigned the responsibility to manage water development including irrigation, water appropriation rights, hydrologic surveys, and flood control.

By 1937, partly because of the severe drought during the 1930s, it became apparent that a state agency, which would be solely concerned with the problems of water development, was needed. With House Bill No. 125, the 25th session of the legislative assembly created the North Dakota Water Conservation Commission.

Originally the commission had three basic concerns:

1. Water for human and industrial needs and sewage dilution
2. Water for livestock and other farm animals
3. Water for irrigation to insure crop yields

By 1940 the commission, after gaining experience in the field, revised and added to its basic concerns such things as recreation, game and fish uses, and flood control.

In 1968, the commission's name was changed to the North Dakota State Water Commission and six overall goals were established which remain unchanged to date:

1. Water for human needs

2. Water for animal needs
3. Water for irrigation
4. Water for industry, other than that available through municipal supplies
5. Water for recreation and wildlife
6. Water control to avert floods

When the commission was first organized in 1937, the board of directors consisted of the North Dakota governor and six appointed members. Since that time, the number of members has varied. Today the commission consists of the governor, seven appointed members, and the commissioner of agriculture as an ex-officio member (Figure 2).

ORGANIZATION OF THE NORTH DAKOTA STATE WATER COMMISSION

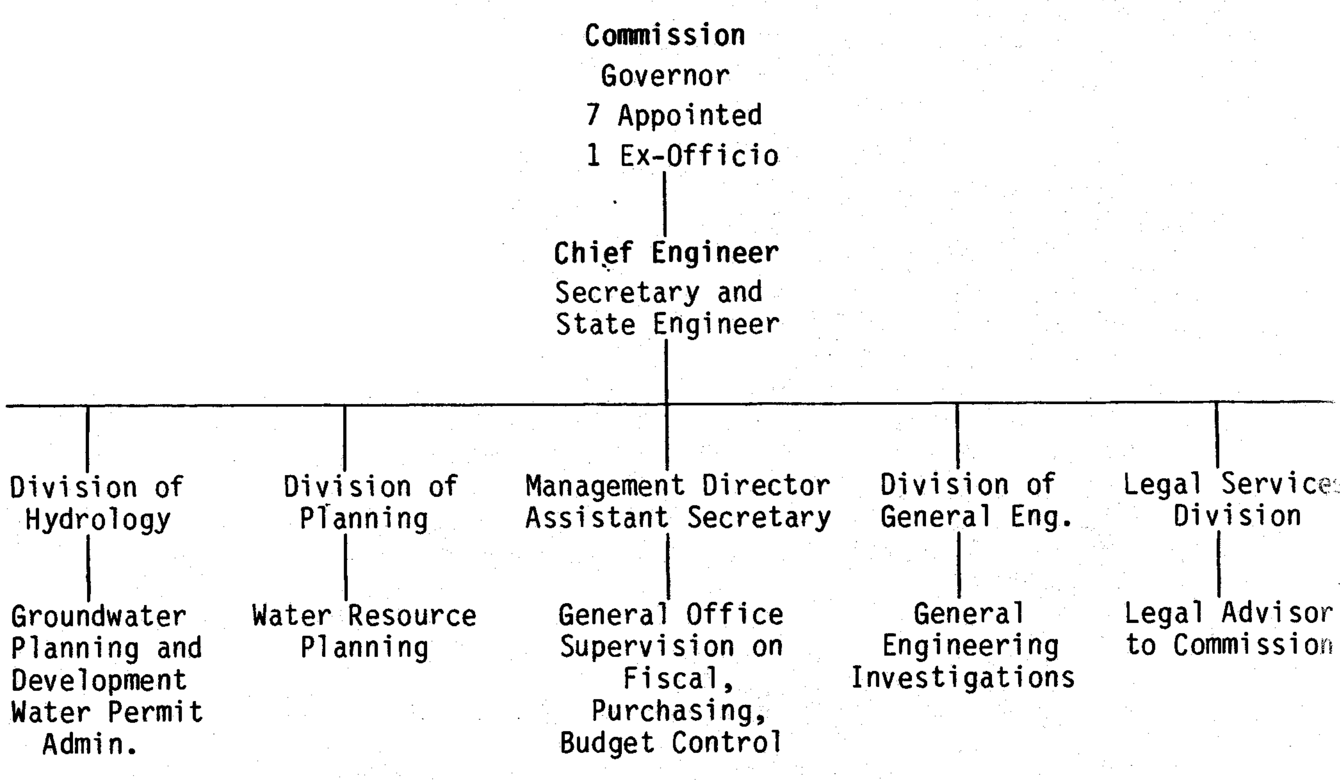


Figure 2. Organization of the North Dakota State Water Commission

SOURCE: North Dakota State Water Commission Biennial Reports, 1981-1983.

In the beginning, mainly because the commission was concerned almost exclusively with small localized projects, the employees were mostly construction engineers, construction personnel, survey crews, and administrative personnel. During the summer months, temporary survey assistants and construction crews were also hired. By 1950, a planning coordinator had been hired. But generally, until about 1960, construction engineers were the mainstay of the commission. The 1960s saw an expansion of the commission and a change in the type of personnel hired. Geologists, hydrologists, draftsmen, research assistants, lab technicians, soil technicians, chemists, and water rights technicians all became a part of the commission. These personnel changes gave the commission a broader perspective and made projects more consistent with the overall goal of improving the water resources in North Dakota (Figure 3).

During its early years, the commission dealt almost exclusively with small, private irrigation projects. Such projects were fairly easy to construct and benefits could be realized quickly. Over time, the commission has become involved in almost every aspect of water development that had relevance to North Dakota (Figure 4). Although the commission does get involved in cost-sharing, it does not own any water development projects. All projects built to date are owned either by local or regional entities or by the federal government. Some of the functions of the commission today are

1. Cost-sharing for construction and for repair and maintenance of large and small dams, drains, and irrigation projects.

2. Evaluation of projects before, during, and after construction.

3. Coordinating various activities with federal agencies. Good examples are working with the United States Geological Survey in conducting groundwater surveys and stream flow data.

4. Organizing entities concerned with water resources.

5. Cooperating with counties, flood control districts, irrigation districts, user associations, and other organizations concerned with water developments.

6. Administering state water laws and managing water permit applications.

7. Representing North Dakota in planning activities involving other states, for example, Missouri Basin States Association.

8. Representing the state in negotiation with federal agencies.

9. Promoting water development in North Dakota at state and federal levels.

The commission's budget allocation has seen a slow but steady increase since the 1930s (Figure 5). In real dollars the budget has remained fairly constant since the late 1960s, while in nominal terms it has increased rapidly.

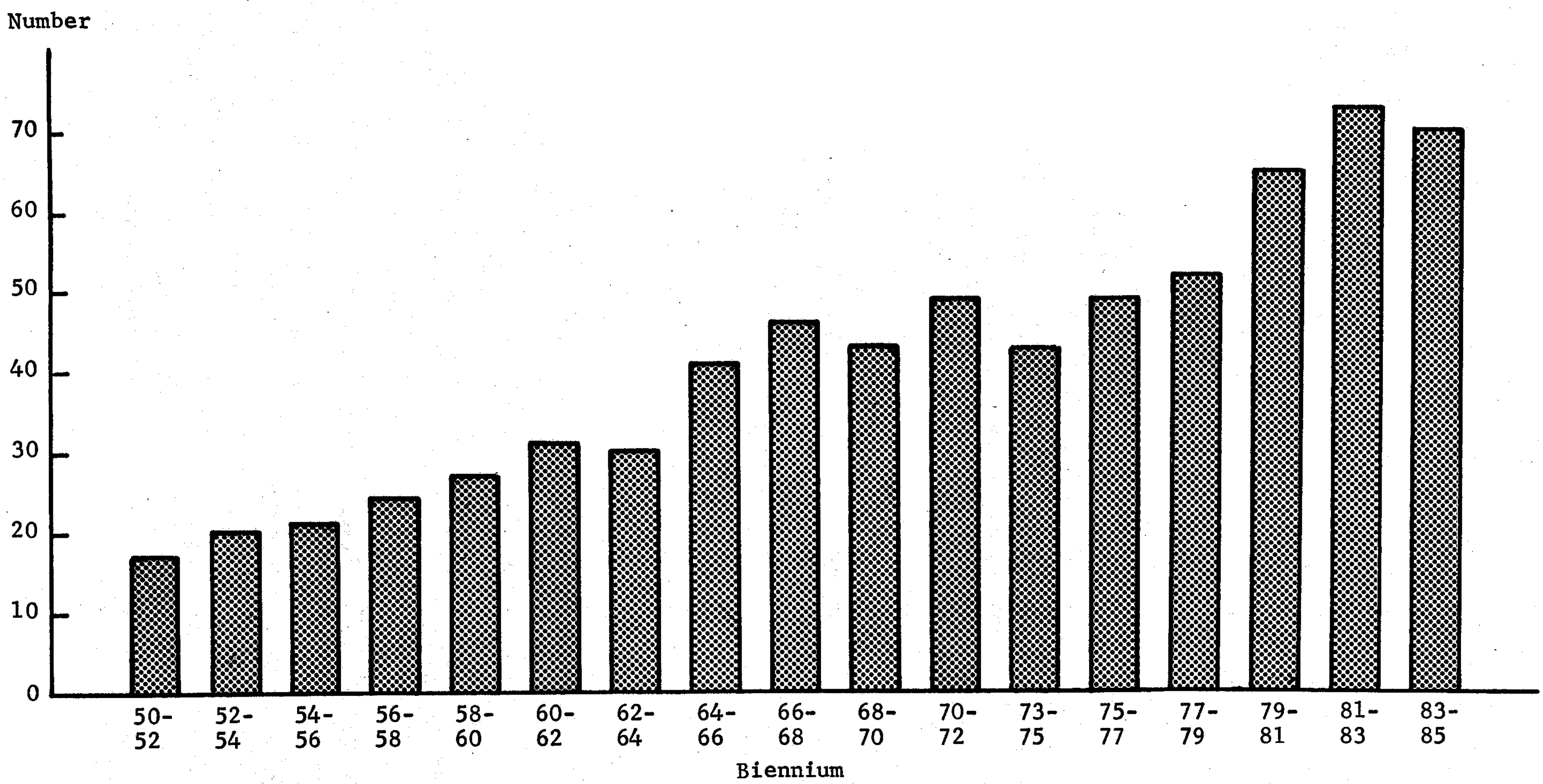
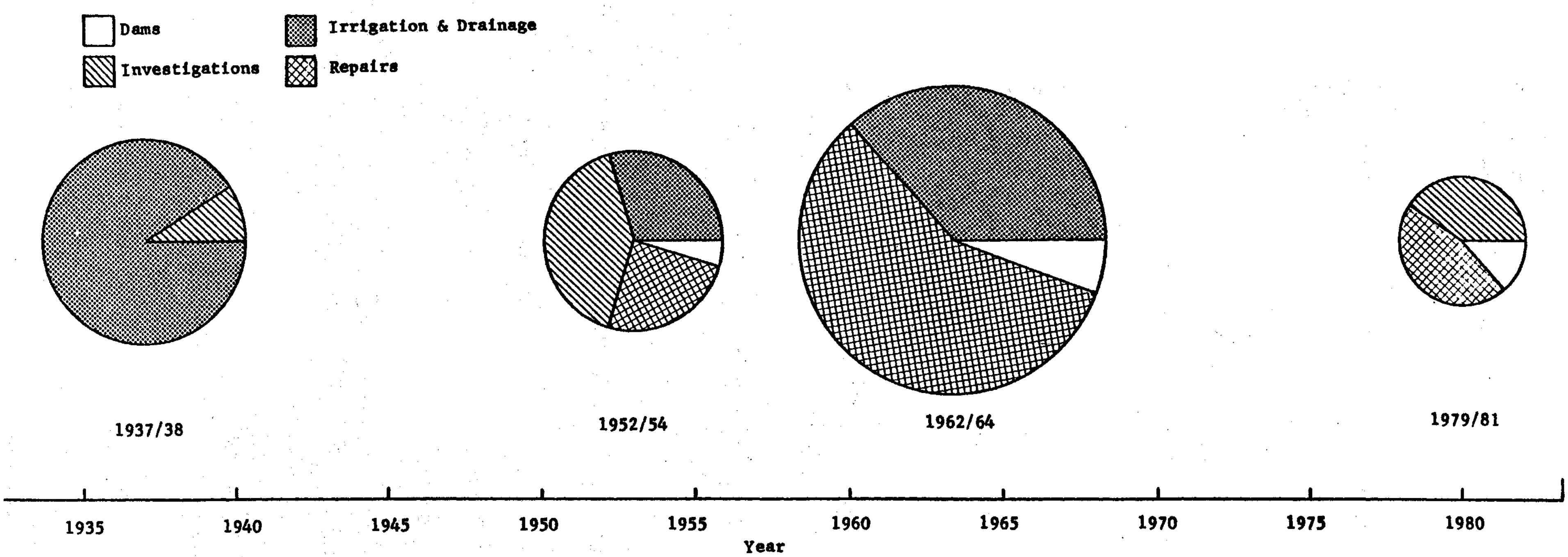


Figure 3. North Dakota State Water Commission Employees, 1950 to 1985

SOURCE: North Dakota State Water Commission Biennial Reports, 1950 to 1983.



Size of circles reflects relative number of projects/activities

Figure 4. Project Involvement of North Dakota State Water Commission, Selected Bienniums

SOURCE: North Dakota State Water Commission Biennial Reports, 1935-1981.

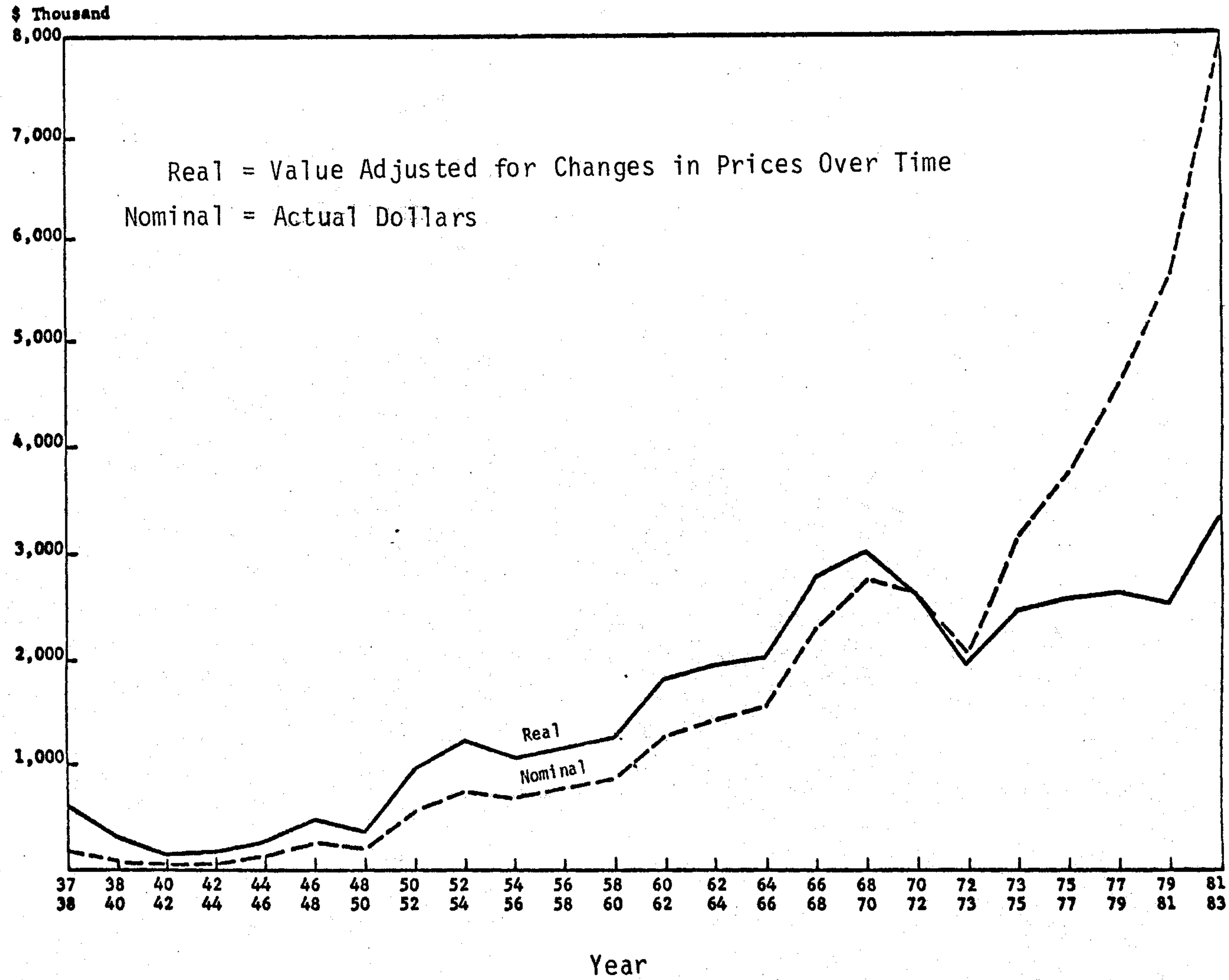


Figure 5. Budget Allocation for the North Dakota State Water Commission, 1937 to 1983

SOURCE: North Dakota State Water Commission Biennial Reports, 1937-1983.

ECONOMIC CONCEPTS

One objective of this section is to outline basic economic concepts common to both private and public investment decision making.[1] A second, more important objective is to illustrate differences between public and private sector objectives and consequent differences in methods of analysis.

The rationale for investment analysis is based on two fundamental economic concepts: scarcity and substitution. The concept of scarcity implies that the natural, man-made, and human resources needed for producing desired goods and services are limited. If these resources were not limited, it would be possible to produce all goods desired by society and no decisions regarding their use would be needed.

Substitution implies that individuals and society are generally willing to trade off between different combinations of goods and services. The problem lies in deciding which goods and services should be produced. These decisions are made partially by judging the trade-offs in the context of their benefits and costs. Benefits of goods and services are their value to consumers. Costs are essentially foregone benefits from consumption of some other good or service.

Present Value

The concept of present value is of central importance in economic analyses. Benefits and costs from projects may not accrue immediately but rather over a period of time. Since a dollar received today is worth more than a dollar received in the future, future streams of costs and benefits must be reduced to a present-day value.

The difference between present and future dollar values is dependent upon the interest or discount rate. For example, the higher the interest rate, the more a dollar will return in the future if loaned with interest. This logic can also be reversed so that if future costs and benefits are known, and the interest rate is given, their present value can be calculated. This relation between present and future values can be formally expressed as follows:

$$PV = \frac{F_t}{(1 + i)^t}$$

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[1] There are several books which provide extensive treatment of resource economic concepts applicable to public sector water development (e.g., Randall 1981; Seneca and Taussig 1979; James and Lee 1971; Howe 1971; Easter and Waelti 1980; Anderson and Settle 1978; Bromley, Schmidt, and Lord 1971).

where PV = present value

F = future dollar value of benefits and costs

i = interest (discount) rate

t = time period in which benefits or costs accrue.

If benefits or costs occur over a series of years, the present value is obtained by summing the present value of each component of the cost or benefit streams. This summation process can be expressed as follows:

$$PV = \sum_{t=1}^{T} \frac{F_t}{(1 + i)^t} \qquad \text{or } F = \frac{1 - (1 + i)^{-T}}{i}$$

where T represents the life of the project.

The actual calculation of present values can be simplified through the use of present value tables such as Tables A1 and A2 (see Appendix A). For instance, consider a project which would yield benefits in year 5 worth $2,000. If a 7 percent discount rate is selected, the present value (PV) of these benefits could be expressed as

$$PV = \frac{\$2,000}{(1.07)^5} = \$1,426.$$

This problem can be simplified by referring to Table A1 which reveals the present value of $1.00 for alternative time periods and discount rates. The present value factor for year 5 and a 7 percent discount rate is 0.7130. Consequently, the present value of $2,000 received in year 5 is $1,426, or $2,000 x 0.7130.

Consider another project which produces a time stream of annual benefits (received at the end of the year) equal to

$1,000 $2,000 $4,000 $3,000.

If a 7 percent discount rate is used, the present value of the benefit flow is

$$PV = \frac{\$1,000}{(1.07)} + \frac{\$2,000}{(1.07)^2} + \frac{\$4,000}{(1.07)^3} + \frac{\$3,000}{(1.07)^4}.$$

The arithmetic involved in this example can be reduced by using the present value factors in Table A1. For example, the entry in Table A1 that corresponds to year 1 and 7 percent is 0.9346, while the entry corresponding to year 2 and 7 percent is 0.8734. Thus, the present value of project benefits is

$$\$8,235 = (\$1,000 \times 0.9346) + (\$2,000 \times 0.8734) + (\$4,000 \times 0.8163) + (\$3,000 \times 0.7629).$$

The computation of present values can be simplified even more if the annual flow of either benefits or costs is expected to be constant from year to year. Consider, for example, the following four-year time stream of benefits:

Year 1 - $5,000
Year 2 - $5,000
Year 3 - $5,000
Year 4 - $5,000

The present value of this benefit flow is

$$PV = \$5,000/(1 + i) + \$5,000/(1 + i)^2 + \$5,000/(1 + i)^3 + \$5,000/(1 + i)^4$$

which can be rewritten as

$$PV = \sum_{t=1}^{4} \frac{5,000}{(1 + i)^t} = 5,000 \cdot \frac{1 - (1 + i)^{-T}}{i}.$$

Once a discount rate is selected, we need only to refer to Table A2 which reveals the present value of $1.00 received annually (or paid annually) for alternative time periods and discount rates. For example, if the discount rate is 7 percent, the present worth factor is 3.3872 (see the entry in Table A2 corresponding to 4 years and 7 percent). Consequently, the present value of the four-year stream of benefits in this example is $16,936, or $5,000 x 3.3872.

By following these formulas, it can be observed that the higher the interest (discount) rate, the lower will be the present value of future costs and benefits. This can be further illustrated through use of a simple example (Figure 6). Consider a water project which generates benefits worth $1,000 each year during its 50-year life span. If future benefits are not discounted, total present value of all benefits would equal $50,000 (represented by the area under Curve A in Figure 6).

However, if a 4 percent discount rate is used to reflect the fact that a given sum is worth less in the future than it is today, then the present value of all benefits would be $21,482 (represented by the area under Curve B). If an 8 percent discount rate is used, the present value of all benefits would decrease further to $12,234 (the area under Curve C).

This demonstrates that <u>selection of the proper discount rate for public investment projects is a crucial step</u>. The situation becomes more critical when costs are concentrated at the start of a project but benefits are spread more evenly over time. This is frequently the case with water

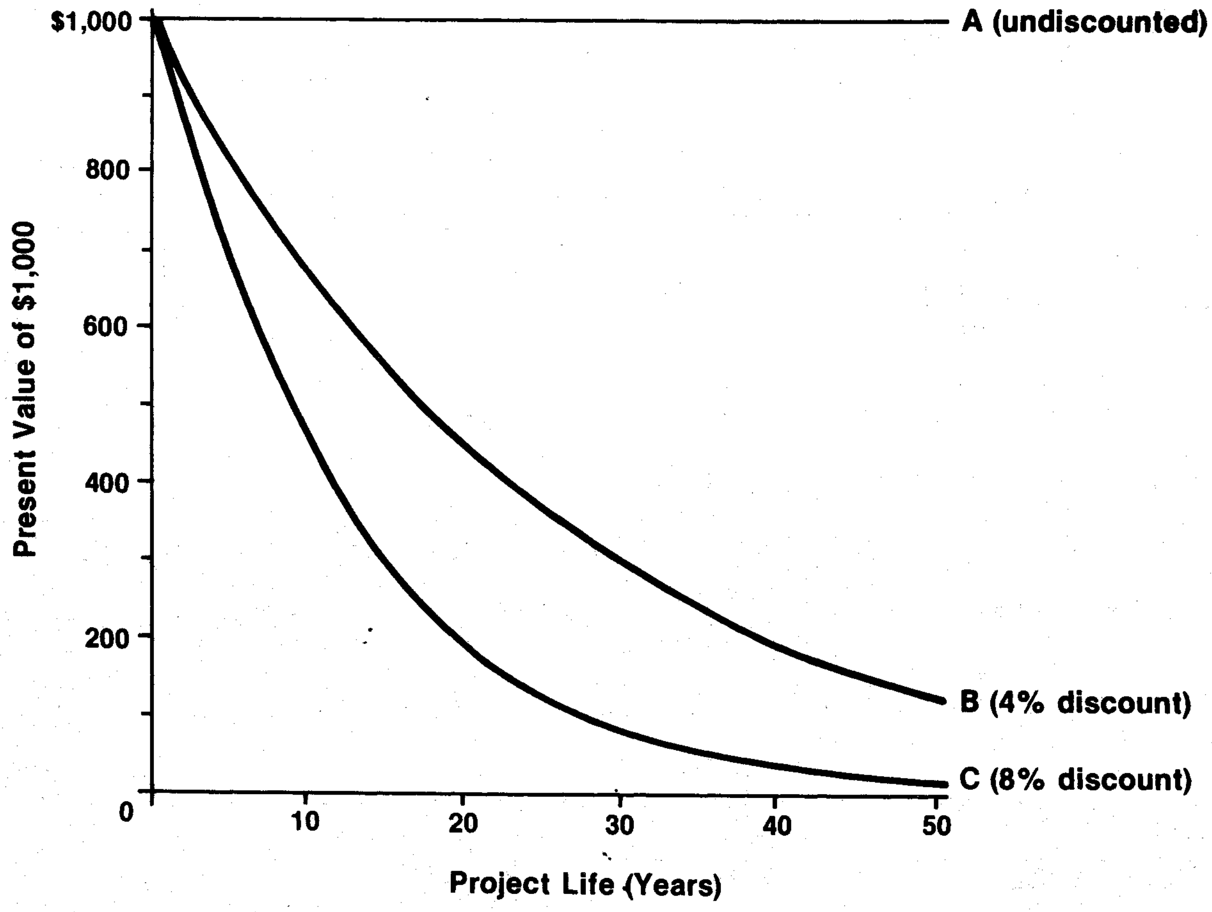

Figure 6. Effect of Discount Rates on Present Value of Future Benefits

resource development projects which have construction costs occurring at the start but benefits occurring throughout the project life.

Selection of an interest or discount rate contributes greatly to determination of whether a project is deemed economically efficient or not. Therefore, there has been considerable controversy regarding appropriate rates. Lower interest rates will make projects appear more worthwhile and will favor long-lived projects over short-lived ones. While it is not within the scope of this report to suggest a proper discount rate, a presentation of alternative approaches to the determination of the discount rate is warranted.

Two main approaches are used in selecting proper discount rates for public investments:

1. Opportunity cost of public capital
2. Social rate of time preference

The opportunity cost approach suggests that the discount rate should reflect the cost of funds withdrawn from the private sector of the economy. Therefore, the discount rate should be equivalent to current market interest rates.

The alternative approach argues that private sector investments consider only private benefits and costs, with no consideration of social benefits or the benefits to future generations. The social rate of time preference approach contends that the discount rate should be a policy tool reflecting governmental objectives and, therefore, should be lower than current market rates. Pagoulatos and Walker (1976) present a useful review of these two opposing positions.

Private Sector Analysis

A major theme in this report is economic welfare, defined as the economic well-being of society. The welfare of a single individual is the simplest example, since only events which affect the individual need to be considered. This is also true of private business firms.

The private sector objective function is typically assumed to be profit maximization; therefore, there is an incentive for firms to produce only private goods for which there may be a potential profit. A pure private good is one which can be withheld from consumers who refuse to pay (exclusion) and whose consumption by one person reduces its availability to someone else (no shared consumption). Everyday examples of pure private goods would include automobiles, televisions, and food.

Benefits and costs in the private sector typically are measured by money received or prices paid in the marketplace. The price and market system performs to direct <u>what</u>, <u>how</u>, and <u>for whom</u> to produce. This system works reasonably well for private individuals and business firms acting in their own self interest. However, it includes only private values and not the value accruing to other sectors of society.

Public Goods

There is another class of goods, public goods, which the private sector does not have the incentive to produce in amounts desired by society. A pure public good cannot be withheld from consumers who refuse to pay (nonexclusion), and consumption of that good by one person does not reduce its usefulness to someone else (shared consumption). Examples of pure public goods include environmental quality, national defense, and flood control. Due to nonexclusion and shared consumption, private firms have no means of profiting from production of public goods even though society may value these goods highly.

Externalities

Firms in the private sector respond only to private profits and costs. Therefore, an incentive exists to allow some costs of production to spill over onto other sectors of society. These spillover costs (externalities) do not accrue to the firm that produces the good but are imposed on part or all of society. Externalities exist because of a lack of enforcement of property rights or society's failure to adequately define property rights for some resources. For example, air and water resources are considered common property resources. These resources cannot be withheld from consumers who refuse to pay (nonexclusion); however, their consumption by one person does reduce their availability to others (no shared consumption). Private firms and individuals are able to use these resources to their own benefit while passing part of the cost of their use on to society.

Externalities can be either a negative or a positive effect and are not limited to private sector actions. Instead, this concept is meant to encompass any benefits or costs imposed on individuals who play no part in the decision. For example, consider a typical water resource project in which a dam is built for flood control. This action may have destroyed a popular fishing area for local anglers (negative externality) but may have created a new waterfowl hunting location (positive externality). Both the anglers and hunters are affected by this project although neither had a decision-making role.

Public Sector Analysis

Failure of the private sector to produce public goods and services in amounts desired by society has prompted government to become involved. State and federal governments have had extensive participation in water resource development, supply of recreational sites (e.g., national parks and national forests), and establishment of environmental quality programs.

The objective function of the public sector is to maximize the welfare of society as a whole. This becomes more complex than private sector analysis, because an event which increases the welfare of one individual may decrease the well-being of another. Consider once again the example of a water resource project that destroys a popular fishing location but creates a new hunting area. Private planners often ignore these externalities in their project analysis. However, public investment decision making should include externalities and other nonmarket effects in addition to traditional market impacts.

The concept of maximizing the welfare of society is too broad to be an effective guide in water resource planning and evaluation. Therefore, objectives which have been used recently to guide public sector planning include the following (U.S. Water Resources Council 1970):

1. Enhance economic development (economic efficiency)
2. Enhance the quality of the environment
3. Enhance social well-being
4. Enhance regional development

Government provision of goods and services does not necessarily guarantee the correct allocation of resources. Government agencies with a limited budget can implement one project only at the expense of other projects. Consequently, it becomes necessary to estimate if the project in question generates benefits (financial and otherwise) in excess of its costs to society. It is also important to compare these four critera among alternative projects.

Several methods may be used to evaluate and rank proposed public projects. Most methods are based on identifying and measuring all project benefits and costs. Both benefits and costs should be measured in dollar values and reflect the relevant social values of project inputs and outputs. This is important since relevant social values should include all that is lost or gained by society as a result of the project. Benefits are not simply the revenues earned by the project, nor are costs just the money spent to construct and maintain the project.

Benefit-Cost Identification

Any water resource project will result in a number of impacts affecting many types of individuals or groups. Project evaluation requires a comparison between events predicted to occur if a project is built and those predicted to occur without project construction. This principle requires prediction of baseline changes which would occur even if the project is not built (generally referred to as the future without condition) as well as changes if it is built.

Project impacts affect society and three subsets: owners, users, and regional economies. In order to correctly define the economic viability of water projects, it becomes necessary to identify and describe the associated impacts for each group. Public sector water development generally suggests that a body of government will be the owner of the facility. Users of the project may include farmers, as in the case of an irrigation project, property owners for a flood control project, and anglers, campers, etc., for a recreational impoundment. For purposes of this study, the regional economy will be identified as a multicounty area surrounding the project development site, while society will be considered to be the state.

Because benefits and costs stem from so many kinds of effects, a systematic procedure is required to ensure each effect is considered and evaluated. Two basic types of impacts will accrue from water resource projects: direct and secondary effects (Figure 7). Direct effects are the goods and services directly produced by the project. Examples would include reductions in flood damages, increased crop production as a result of irrigation, or increased recreational opportunities. Direct effects accrue from the physical impacts of the project.

Water projects will have secondary (indirect or induced) effects on other parts of the economy. Some project inputs, which will be purchased locally, may increase local economic activity. Irrigation water, flood protection, and outdoor recreation provided by a project will also expand local business activity and provide added employment opportunities to the local labor force.

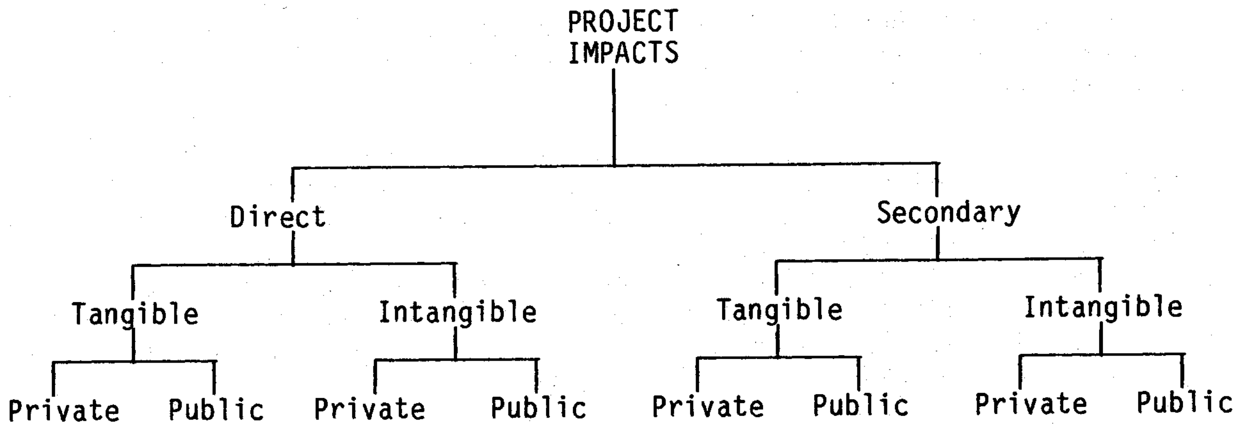

Figure 7. Categorization of Project Impacts

Secondary impacts are those resulting from value-added activities influenced by the project through economic linkages and may stem from either forward or backward production linkages. Secondary impacts result from forward production linkages that increase net income of those who process the production output. The net impact is income from processing project output minus the sum of income which would be obtained from processing output displaced by the project and output which would have resulted without project implementation. Secondary impacts also result from backward production linkages which increase net income of those who provide goods and services to the project area. These net impacts are the increased income of those serving the project area minus the reduced income of those who would otherwise provide input for alternative and displaced services.

These initial rounds of forward and backward linkages may be described as the initial round of secondary impacts. These processors and suppliers of goods and services will require a set of inputs from other firms in the economy. This will cause additional linkages and successive rounds of spending with yet additional firms until demand for goods and services by all affected firms is satisfied. This is the "multiplier" process.

Water project development results in primary and secondary employment impacts. Primary employment impacts will result from jobs created to construct, operate, and maintain the project and from employment requirements of project users (i.e., construction of an irrigation project may result in additional employment requirements on-farm because of increased intensity of agricultural production practices). Additional employment impacts also will result from secondary impacts of indirect and induced expenditures resulting from forward and backward linkages of the economy.

There has been some controversy surrounding the extent to which secondary impacts can be counted as project benefits. A public water project will likely have positive secondary effects, but negative secondary effects will also be present since money must be withdrawn from the private sector (taxes) to finance the public project. When resources of the economy are fully employed and mobile among jobs, positive secondary effects of a new public project should not be expected to be any greater than the negative secondary effects of reduced private spending.

Estimating the extent of direct and secondary impacts is rarely without complications. For example, the economic impact of recreation expenditures is frequently cited as a justification for planned water development projects. However, projected benefits are rarely compared with the actual economic impact data obtained following a project's completion. Gramann (1983) compared the predicted and actual economic impact of recreation expenditures at an Illinois reservoir and found several problems associated with prereservoir economic impact assessments.

One problem encountered was an overestimation of the number of visitors to the site. This was caused by an overestimation of the total population near the reservoir and failure of planners to consider the influence of several competing recreational sites. A more serious criticism of early impact assessments was that planners ignored the probability that only a portion of the expenditures would be retained as net income in the area where the reservoir was located. Much of the goods and services sold locally to recreationists had to be imported from outside the region. Planners and supporters also failed to distinguish spending by area residents from that by nonlocal visitors. Expenditures by local residents that probably would have occurred in the area without the project cannot be counted as an economic impact.

Technical Quantification of Benefits and Costs

The second step in project analysis, after all social costs and benefits have been identified, is to quantify the inputs and outputs in technical (not monetary) terms. This requires estimation of the physical inputs and outputs specified for each year of the project's expected life.

Monetary Quantification of Benefits and Costs

The third step in public sector project analysis is to attach money values to project inputs and outputs. Both direct and secondary effects described earlier can be divided into tangible (monetary) and intangible (nonmonetary) components. Tangible effects include those project consequences which can be quantified in traditional dollar terms, such as the project's construction, operation, and maintenance costs and the users' construction, operation, and maintenance costs or user fees.

Intangible effects are project outputs for which market prices are nonexistent and for which it is not possible (at the present time) to infer what users or consumers are willing to pay. Examples of nonmonetary impacts include improved aesthetics, preservation of scenic areas, or saving of lives.

Benefits and costs can be grouped into four types that reflect the ease with which dollar values can be determined (Howe 1971):

1. Benefits and costs for which market prices exist and for which these prices accurately reflect social values. Examples include most agricultural inputs and agricultural commodities that are not subsidized.

2. Benefits and costs for which market prices exist but may not actually reflect social values. Examples include price-supported agricultural crops or inputs whose production generates pollution that does not include the social cost in its price.

3. Benefits and costs for which no market prices exist but for which appropriate social values can be approximated in money terms by inferring what consumers or users would be willing to pay if a market existed. An example would be outdoor recreation values.

4. Benefits and costs for which market prices are nonexistent and for which it would be difficult to imagine any kind of market-like process capable of registering a meaningful monetary valuation. Examples include values associated with aesthetics or environmental quality.

Market Price as Measure of Benefits and Costs. The most obvious way of measuring explicit project benefits is to use the market value of the goods and services produced. For example, an irrigation project may produce alfalfa, corn, or other commodities having a market value. Prices may vary over time but they are available.

If market values are used, these prices should be computed for the point of production and not for some distant market (ultimate market prices should subtract transportation costs). In addition, if project output is large enough to depress prices, this impact must be addressed.

Price/cost levels which vary over time should be measured in dollars of some base year or should be converted to a constant dollar figure. The price of an item in 1972, for example, is not the correct price to use in an analysis if all other values are expressed in 1983 dollars. These price levels can be converted to a constant dollar by using an inflator or deflator such as the Consumer Price Index (CPI) or the Wholesale Price Index (WPI). (The Bureau of Labor Statistics in the Department of Labor publishes these indices.) Construction costs for water projects can be adjusted using construction cost indices found in the Engineering News-Record (a construction weekly published by McGraw-Hill, Inc.).

Simulation of Market Prices. Market prices work to indicate what people are willing to pay for goods or services, and this willingness to pay can be used as a measure of social value or benefit. However, there are some goods or services for which usual market prices do not exist (nonmarketable outputs). Examples include outdoor recreation, flood control, and preservation of unique areas. Although markets for these goods do not exist, it may be possible to infer what consumers or users would be willing to pay based on observed behavior or reasonable assumptions concerning people's value systems.

Take, for example, the benefits from flood control. Although there is no market price for flood control, it can be reasonably assumed that floodplain occupants would be willing to pay any price up to the full amount of expected damages that would occur without the project.

Another example of simulating the operation of a market is found in estimating the value of public recreational opportunities. If participants are required to pay for the use of a recreational facility (user fee), this amount may reflect only a portion of what these individuals are actually willing to pay. The difference between what consumers must pay in the market and what they would be willing to pay is consumer's surplus. Thus, one possible estimate of the total social benefit of the recreational opportunity is the value of the user fee plus consumer's surplus.

To illustrate the concept of consumer's surplus, we refer to the demand curve for product X in Figure 8. The demand curve is a basic tool used to measure the willingness to pay for goods or services. It reveals the relationship between the amounts of a certain good that will be purchased per period of time at various prices with all other relevant variables such as income, tastes, and the prices of other goods held constant. In Figure 8, the demand curve for product X measures the price of X along the vertical axis and the quantity per time period along the horizontal axis. At prices of $10, $8, and $6, the quantity demanded per period of time will be 6, 7, and 8 units, respectively. If the price of product X were to fall--for example, from $10 to $8--but everything else that could affect demand were to remain the same, then the quantity demanded would increase from 6 to 7.

In Figure 8, if product X represents some measure of recreation service available, and only 7 units were available per time period, the market price will be $8. However, the market price is only what consumers have to pay on the market, it is not a measure of their total willingness to pay. If there were only 6 units available on the market, some people would be willing to pay up to $10 rather than go without the product. Consequently, at a price of $8, these consumers are getting a bonus of at least $2, because they are able to purchase the good for a price less than they would be willing to pay. This bonus is referred to as consumer's surplus, and when the price is $8 it can be represented by the shaded area in Figure 8.

There are several methods used in estimating what users are willing to pay for goods and services in the absence of market prices (O'Connell 1977). The survey-based method estimates values from responses to a questionnaire or personal interview. The travel-cost-based method estimates demand by observing users' expenditures and distance travelled in pursuit of their activities.

Nonmonetary Impacts. There are some project effects for which no monetary value can currently be estimated either in the market or through a surrogate. Examples include benefits associated with aesthetics and with many aspects of environmental quality. Even though these impacts cannot be expressed in traditional value terms, they should be a part of the evaluation process.

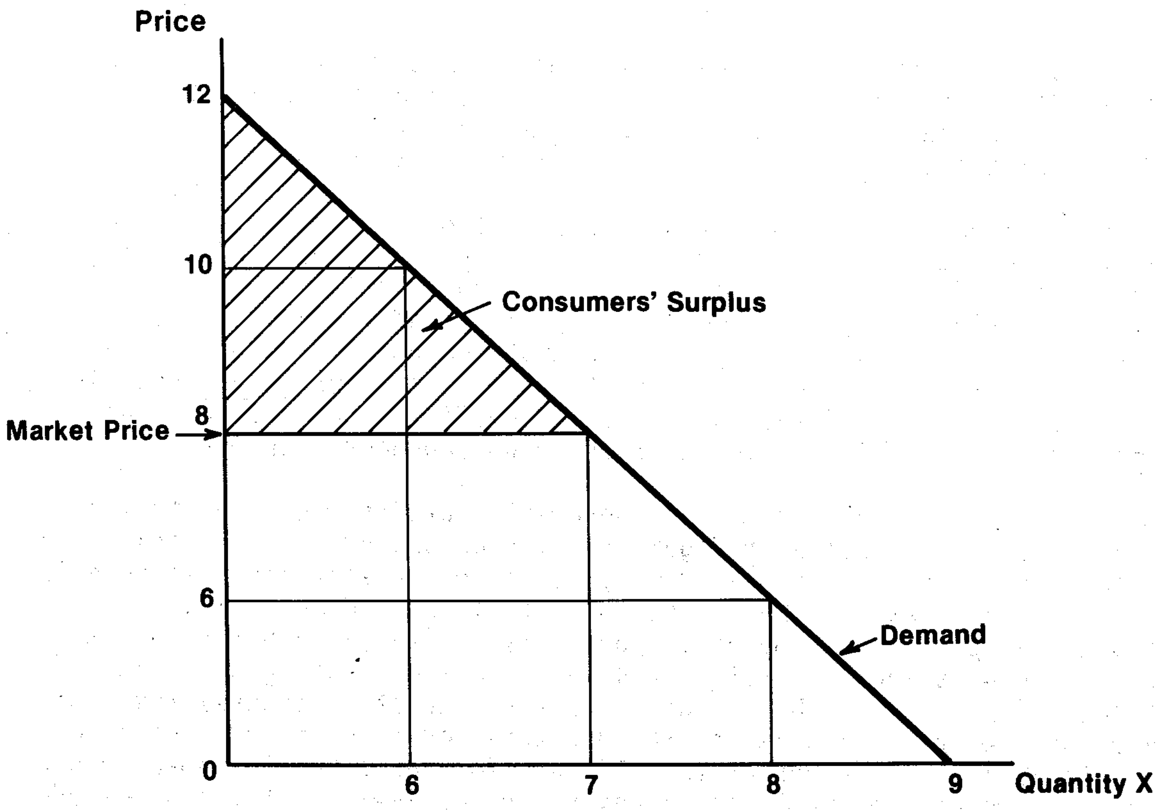

Figure 8. The Demand Curve and Consumers' Surplus

There are several major areas of environmental concern that are often impacted as a result of water project development. A selected list presented by Howe (1971) includes the following:

1. Water quality
2. Air quality
3. Thermal pollution
4. Preservation of natural and wilderness areas
5. Preservation of features of scientific value
6. Visual and landscape aesthetics
7. Preservation of wildlife and wildlife habitat
8. Noise pollution

The incorporation of environmental and other nonmonetary impacts into project design and evaluation can be best accomplished by presenting impacts in physically descriptive terms. Positive as well as negative implications must be described to gain a total picture of the ramifications of a project. Although this adds nothing to the evaluation of economic efficiency, it does provide additional information by which projects can be evaluated.

Summary

In summary, the primary differences between private and public sector investment analyses are:

1. The public viewpoint incorporates all costs and all benefits to whomever they occur.

2. The public sector discount rate may be different than that used by private firms because all social benefits and benefits to future generations need to be considered.

3. When market prices do not accurately reflect what consumers or users are willing to pay, private analysts use market prices in their analyses, but government analysts should evaluate the total economic worth of each input and output.

4. When analyzing projects which produce nonmarketable outputs, the government analyst should attempt to derive a surrogate market value for these outputs. A private analyst is interested only in marketable outputs which can contribute to profitability of the investment.

Impacts included in the economic analyses of public sector water development projects can be divided into four categories: private direct impacts, public direct impacts, private secondary impacts, and public secondary impacts. Direct impacts are those values obtained from project-produced goods and services and accrue from the project's physical effect on owners and users. Secondary impacts are realized through value-added activities influenced by the project through economic rather than technological linkages. Private direct impacts are those which directly affect private sectors of the economy, such as farmers in the case of irrigation development. Public direct impacts are those which directly affect the public sector, such as project construction costs if the public pays for project development. Private indirect impacts are those impacts which accrue indirectly from project development, such as increased purchases of retail trade items (e.g., bait, tackle, water skis, etc. in the case of impoundment development for recreation). Increased tax collections resulting from increased purchases of goods and services are one form of public indirect benefits. Intangible impacts, which cannot be quantified in the economic analysis, should be quantified in physically descriptive terms and be incorporated into the evaluation process.

CONCEPTUAL DESIGN OF WATER DEVELOPMENT ANALYSIS

As discussed earlier, public sector water development impacts have four different values--owner, user, regional, and society. Some of the costs and benefits resulting from project implementation are listed in Table 1. These costs and benefits are subdivided into the four value categories.

TABLE 1. SELECTED COSTS AND BENEFITS OF PUBLIC SECTOR WATER DEVELOPMENT PROJECTS

	Costs	Benefits
User	Expenses to Use	Net Gain in Satisfaction/ Utility ($ Plus Consumer Surplus)
Owner	Expenses to Acquire or Construct	Net Returns on Investment
Region	Public $ Outlays Negative Externalities	Net Changes in Tax Revenues, Total Business Activity, Employment, Personal Income, Positive Externalities
Society (State)	Public $ Outlays	Net Gains in Satisfaction/ Utility

Of the four value types discussed above (owner, user, regional, society), we are most interested in regional and societal values in this report. Owner values are pertinent to analyses of private investments. User values are important to public policymakers but are factored in societal values when appropriate in the project analysis. Even though emphasis is placed on regional and societal values, some of the dollar flows of owners and users are inputs of certain decision-making models.

Recreation Benefits

Recreation values or benefits are of two types: those that accrue to the individual and those that accrue to society. The Water Resources Council (1983) suggests a nine-step procedure for evaluating recreation benefits (Figure 9).

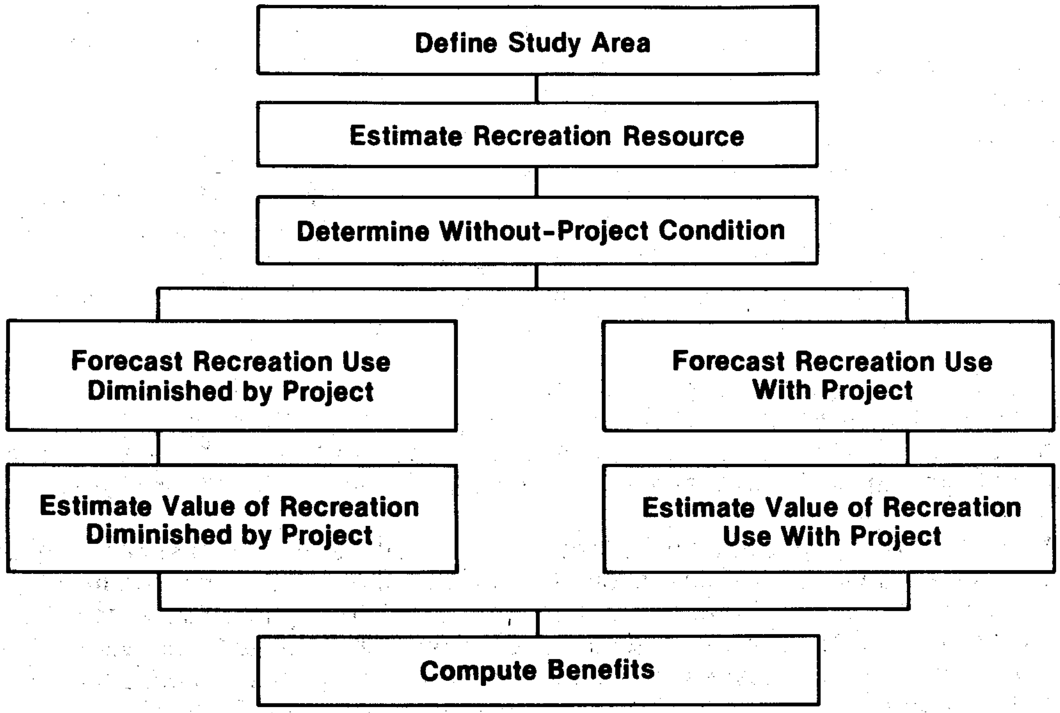

Figure 9. Flowchart of Recreation Benefit Evaluation Procedures (U.S. Water Resources Council 1983)

The two basic types of information needed to evaluate recreation benefits are (1) the net increase in recreation activity expected from the project and (2) the amount project users would be willing to pay for the increased recreation opportunities. Several techniques to estimate expected recreation use are (1) regional use estimating models, (2) site-specific use estimating models, (3) application of information from a similar project, and (4) capacity method of determining use (U.S. Water Resources Council 1983).

Regional use estimating models are statistical models that relate use to the relevant determinants based on data from existing recreation sites in the study area. The site-specific use estimating model relates use to distance traveled, socioeconomic factors, and characteristics of the site and alternative recreation opportunities. Both methods require a considerable amount of data collection and analysis.

If regional or site-specific models are not available and cannot be estimated because of data limitations, then use can be estimated by the "similar project" method. This technique assumes recreation demand for a proposed project can be estimated from observations of visitation patterns at similar, established recreation sites. If this method is used, it is important that the sites be matched as closely as possible in regards to type, size, and quality of the site; market area's demographic and socioeconomic characteristics; existence and location of competing recreation opportunities; and other variables that influence demand. If data are unavailable and not cost effective to obtain for the above methods, and it can be demonstrated that sufficient excess demand exists in the market area, then use may be assumed to be equal to capacity supplied by the proposed project.

The next step of assigning a value to the recreation experiences is not an easy task for the water resource analyst. Individual or private benefits are quantified in terms of increased utility or personal satisfaction enjoyed by recreation participants. The benefits to society are quantified by aggregating individual benefits and should be a measure of the total net value attributable to the recreation experience.

Techniques to quantify private recreation benefits include (1) interim unit-day values, (2) expenditures, (3) contingent value approaches, and (4) travel cost techniques.[2] All methods attempt to measure what recreation participants are willing to pay for project services.

The interim day procedure relies on a fixed value per recreation day selected from a range of values provided in the Water Resource Council's Principles and Standards. These values are meant to approximate the average willingness to pay as judged by planners who select the value. All of the procedures have weaknesses, but the interim unit-day approach is probably the weakest. The artificial range of values will rarely approximate the appropriate estimate of recreation benefits, and these values cannot adequately reflect the real differences between values of recreation for alternative sites and activities.

The expenditure method attempts to measure the value of recreation to the participant based on the total amount of money spent on recreation. These expenditures usually include travel expenses, equipment costs, and expenses incurred at the recreation site. This approach indicates the amount of money spent for recreation activities but does not indicate the value or true net worth of the recreation opportunity.

An analogy would be to argue that the cost of planting, harvesting, and transporting an agricultural crop is an indication of the crop's value, which is not true. The value of the crop is actually the residual payment to the land after all other costs of bringing a product to market are deducted from the final product price.

The <u>gross</u> economic value of a recreation experience is composed of (1) total expenditures by recreation participants, and (2) the value over and above actual expenditures that recreationists would be willing to spend for the recreation experience. These two components provide a measure of the recreationists' <u>total</u> willingness to pay. However, only the willingness to pay <u>in excess</u> of actual expenditures ("net willingness to pay" or "consumer's surplus") can be considered the net value of the recreation experience (Figure 10). The actual expenditures indicate that recreation participants value project services as much as other things they

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[2] More information on the application of economics to outdoor recreation can be found in a report compiled by Hughes and Lloyd (1977).

could have purchased for the same amount. However, if project services were not available, these expenditures would simply be redirected for other goods and/or services in the economy.

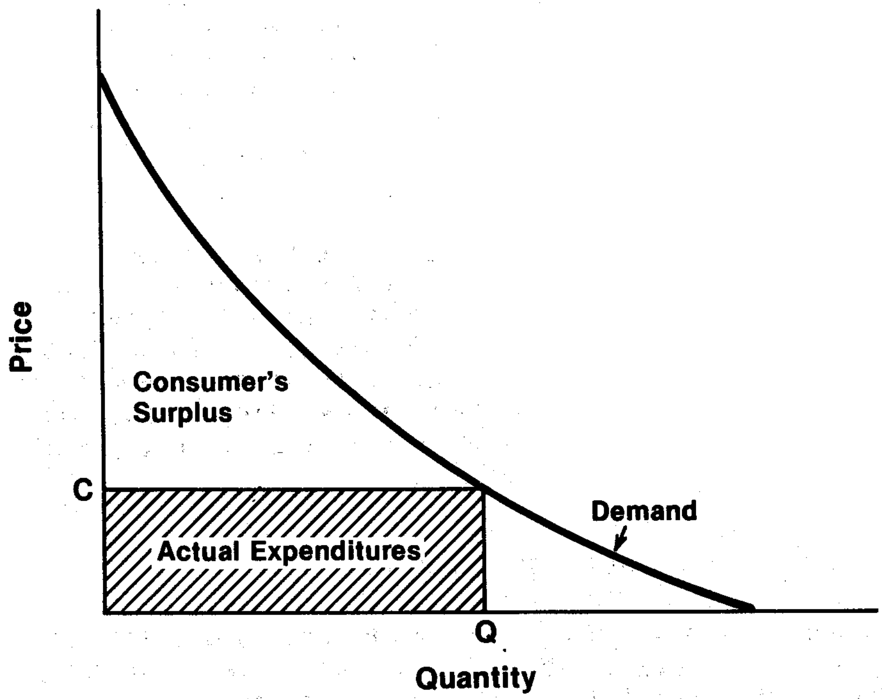


Figure 10. Theoretical Demand Curve Showing Relation Between Actual Recreationist's Expenditures and Consumer's Surplus

Contingent value approaches include various ways of asking recreators or potential recreators their estimates of value. The two most popular are willingness to pay and willingness to sell the right to participate in a particular activity. Situations are often posited wherein the respondent can choose from a range of values or activity options. These approaches, when applied properly, capture the entire private benefit of recreation experiences to participants.

The travel cost technique uses the actual travel cost to and from a site plus time cost incurred during the travel as a proxy for the price of the recreation service. The assumption is that if a person is willing to sacrifice $30 to go 300 miles for a given recreation activity, they would be willing to pay a $10 entrance fee if the same opportunity were 100 miles closer (assuming travel costs were 10 cents per mile). This approach has a strong theoretical basis, but its use is limited by the expense of gathering necessary information and the availability of substitutes. The population of concern must be surveyed, and considerable analysis is required to arrive at defensible values. However, this method captures the entire amount of consumer satisfaction from an experience, including consumer's surplus.

None of these techniques is especially suited to state-level water project analysis. They are either conceptually weak or are intractable.

Therefore, a general rule of thumb for incorporating recreation benefits is needed. Leitch and Kerestes (1982) found that licensed sportsmen in North Dakota placed a personal daily value on their activity four times greater than their variable expenditures and 1.4 times greater than their total expenditure. If we assume the demand curve for outdoor recreation activity is normal, i.e., neither perfectly elastic (no consumer's surplus) nor perfectly inelastic (infinite consumer's surplus), then the net activity or satisfaction can be approximated. A conservative estimate of the level of consumers' surplus (i.e., true net worth) for outdoor recreation is thus 40 percent of total daily expenditures.

This approach can be further supported if we view outdoor recreators as producers as well as consumers. Recreation participants use inputs (e.g., gasoline, time, food, equipment, etc.) to "produce" a recreation experience much like a farmer uses certain inputs (e.g., fuel, labor, seed, etc.) to produce a crop. Thus, the distinction between consumer's surplus (i.e., the difference between what consumers are willing to pay and what they have to pay in the market) and producer's surplus (i.e., profit) is blurred when addressing recreation benefits.

Irrigation Benefits

Irrigation benefits are typically pure private goods, and therefore irrigation projects can be evaluated from a private investment analysis perspective. Users can be excluded, and the cost of additional users is generally greater than zero. A clear definition of the values and/or benefits of public sector irrigation development is difficult. Arguments arise when attempting to quantify the return to water supplied by the project. Benefits of irrigation can be no greater than the total net increase in agricultural returns per unit of land served. However, there are additional inputs to irrigated lands that demand payment as well. Management, for example, is more intense and should be rewarded with a portion of the added return. If forage crops are irrigated then fed to dairy cattle, a significant portion of the benefit can be attributed to the enterprise change.

For the sake of simplicity, an upper limit of the benefits of irrigation is the net increase in crop production revenues on irrigated lands. Conceptually, irrigators should be able to repay the costs of irrigation projects with these added revenues. It remains a political choice whether or not to classify these private benefits as social goods and not require beneficiaries to repay costs. From an economic analysis standpoint the net gain in productivity on irrigated lands should be treated as the benefits to irrigation regardless of who ultimately pays the cost.

Drainage Benefits

Public drainage projects serve both public and private sectors. Public benefits arise in damages prevented to public lands, structures, and transportation systems. Private sector benefits arise in damages prevented and also in enhanced use of drained lands. Unlike flood control, certain elements of drainage projects are pure private goods while some remain public. A main drainage ditch, for example, can generally accommodate an additional user at zero added cost. However, users can be excluded by law from using the ditch, or assessed a fee for its use.

Agricultural drainage benefits can be divided into two categories, depending on whether there is a change in cropping patterns. Damage reduction benefits are the increases in net income that occur where there is no change in the cropping pattern between the with- and without-project conditions. Intensification benefits are those that accrue on lands where there is a change in the cropping pattern. Both damage reduction benefits and intensification benefits can be measured by farm budget analysis. These procedures are presented in greater detail in guidelines published by the U.S. Water Resources Council (1983).

In theory, drainage assessments can be made that equitably assess costs of public drainage projects across beneficiaries according to benefits received. If this is the case, a drainage project can be evaluated purely on an investment analysis basis--Are the users able to repay project costs? However, in cases where assignment of benefits is not clear nor politically feasible, a portion of the private benefits is normally assumed to be public or social benefit. Meeting one or more of the definitional criteria for public goods, the provision of drainage services falls under social benefits.

Flood Control Benefits

Flood control values are the dollar values of flood damages prevented by flood control structures or other nonstructural measures. Flood damages are averted in both the public and private sector. Public sector benefits are clearly (by definition only) public goods and should be valued in terms of dollars saved to the public sector. Examples are dollars saved from not having to repair flood-damaged roads and bridges; dollars saved from government personnel costs by not having to prepare for an expected flood, during a flood, and postflood cleanup; and dollars saved from averted damages to public buildings during floods.

Private sector benefits are a type of private good in that each individual's benefit can be quantified in dollar terms, similar to quantifying public sector benefits. However, most private sector benefits have at least some characteristics of publicness, especially those benefits that, once supplied to one person, cannot be withheld from another person. In other words, if flood control is provided for one group of individuals in a floodplain, an additional resident cannot be excluded from benefiting and the marginal cost of serving another resident is zero. Therefore, most private sector benefits can properly be included as public goods or as social benefits.

The U.S. Water Resources Council (1983) lists ten steps in computing benefits from flood control (Figure 11).

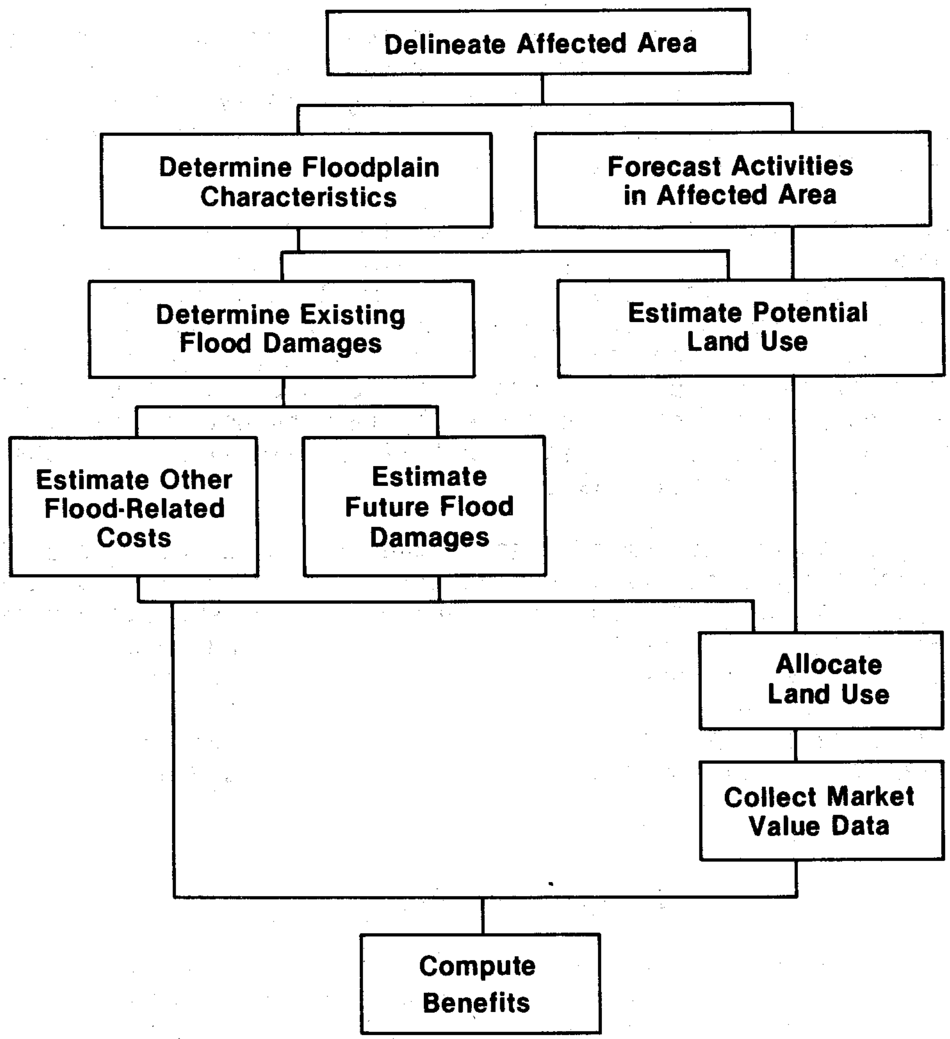


Figure 11. Flowchart of Urban Flood Damage Benefit Evaluation Procedures (U.S. Water Resources Council 1983)

One conceptual problem with valuation of flood control benefits is how to assess development following the flood control project. Typically, development in a floodplain after installation of flood control structures is not counted as a benefit of the project. Flood control benefits, both public sector and private sector, are social benefits, but only to the extent of preproject development.

Economic Decision-Making Models

Project economic analysis is only one step in comprehensive project planning and it is only one of several criteria involved in accepting, modifying, or rejecting a proposal. In addition to the four stated objectives of the Water Resources Council (economic efficiency, regional development, environmental quality, and social well-being), politics play a major role in project planning. However, only three of these objectives--

economic efficiency, regional development, and social well-being--will be discussed in this project analysis context. Each objective will be explained separately in the form of a decision-making model.

Economic Efficiency Decision-Making (B/C) Model

Only regional and societal values are directly considered within the context of public sector economic efficiency:

User - Irrelevant, indicated by choices assuming perfect competition.

Owner - Irrelevant, indicated by choices assuming perfect competition.

Regional - Are benefits to the region greater than costs to the region?

Society (state) - Are benefits to the state greater than costs to the state?

A regional economic efficiency model views project costs, benefits, and associated impacts from the perspective of regional public decision makers. These may be county commissioners, water management district directors, state legislators with constituents in the region, or multi-county boards, or commissions.

Typically, in regional analyses, direct costs borne by local jurisdictions are compared with direct benefits received by individuals and savings of tax outlays by the local taxing jurisdiction. Cost-sharing by state or federal agencies would not typically be included in these analyses by local decision makers. Thus, from a local or regional perspective, a B/C analysis only represents a portion of the total benefits and costs.

A societal (state-level) economic efficiency decision-making model views project costs, benefits, and associated impacts from the state's perspective. Society's (the state's) cost includes all dollar costs of construction, operation, maintenance, and, when quantifiable, external costs. Benefits include all dollar returns to the project, from the values of recreation and flood control, to project revenues such as payments for water, user fees, or tax levies to retire construction debts.

State-level public sector analyses differ from private sector analyses in that benefits of extramarket goods are included. These include values or benefits that do not generate actual dollar flows (such as externalities) but nevertheless are project impacts. In addition, the public sector makes expenditures for society and does not expect to recover all outlays on projects that provide public goods. Public sector water project development costs are "repaid" in returns to society, some of which remain unquantified.

There are several economic efficiency criteria which can be used in accepting or rejecting projects after all benefits and costs have been addressed. The basic measure of economic gains (or losses) from a project can be expressed in the form of present value of net benefits (PV) or in the form of a benefit/cost ratio. Present value of net benefits is the difference between the present value of benefits and the present value of costs (B minus C). The simplest form of the benefit/cost ratio is the present value of benefits divided by the present value of costs (B/C).

With an unlimited budget, it would be desirable to implement all projects for which the PV is greater than zero or the B/C is greater than one. However, when the budget is sufficiently limited so that not all of these projects can be undertaken, then different criteria should be used. In these cases where capital is a restraint, present value of net benefits over capital investment (PV'/k) would be preferred in setting priorities, where PV' is total benefits minus operation and maintenance costs.

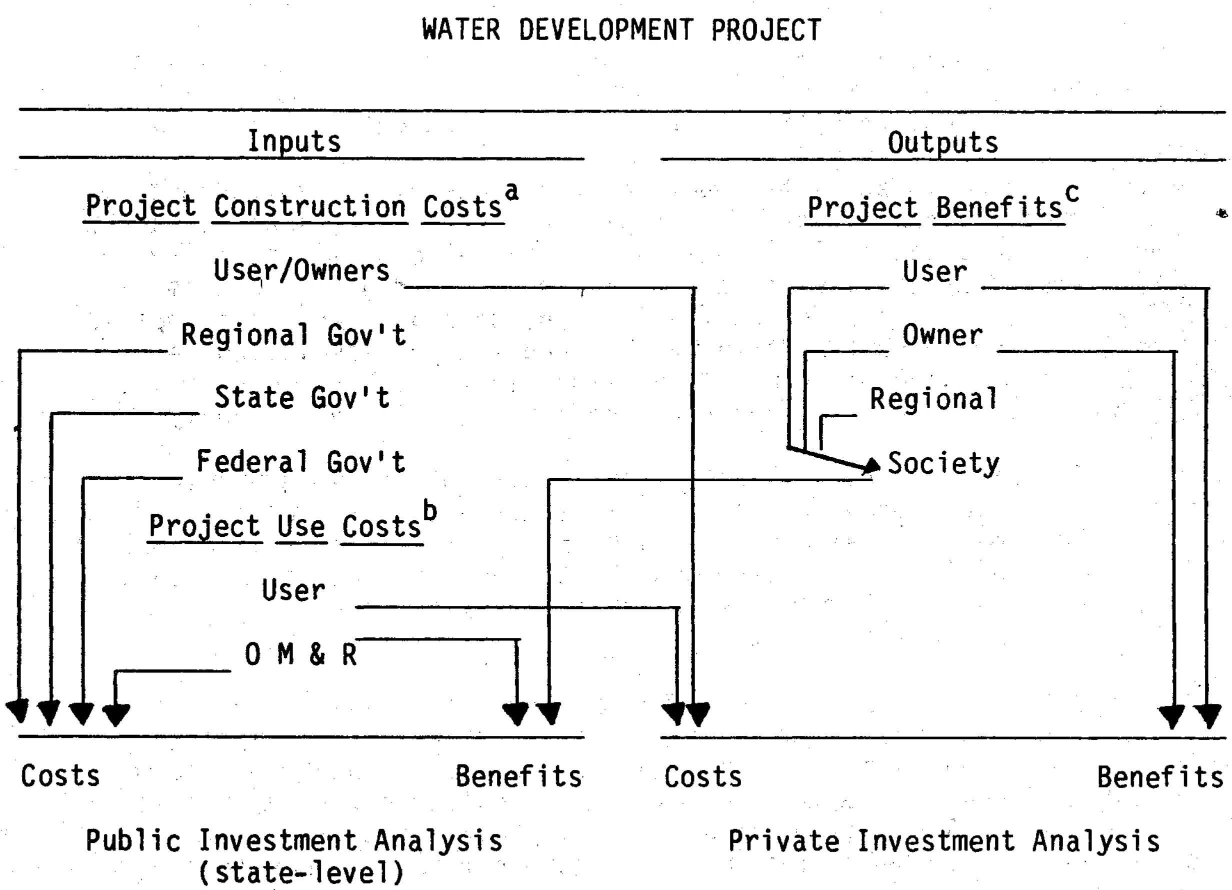
The internal rate of return (IRR) is another criterion which has been used to rank projects. It is defined as the rate of return (or discount rate) that makes present value of net benefits equal to zero. The internal rate of return is the most difficult to use and it might lead to an incorrect ranking of projects when time paths of benefits and costs are quite different. Consequently, this technique has fallen into disfavor for evaluating natural resource investments.

Table 2 summarizes some important characteristics of each technique. The different strengths of the procedures suggest that more than one technique should be used in project analysis. This report will focus on the use of present value of net benefits and the benefit/cost ratio in the economic efficiency decision-making model.

TABLE 2. CHARACTERISTICS OF ECONOMIC EFFICIENCY CRITERIA

Characteristics	PV	B/C	PV'/k	IRR
Discount rate determined	Externally	Externally	Externally	Internally
Measure of volume	Yes	No	No	No
Breakeven point	0	1	1	Selected rate of return
Difficult to calculate	No	No	No	Yes
Usefulness in ranking projects	Yes, when k is about equal for all projects	Has the most weaknesses	Yes	Yes, if the time path of benefits & costs are the same for all projects

Figure 12 illustrates the relationships among the four value types, the economic efficiency criteria (benefit/cost ratio), and the perspectives of public versus private sector investment analyses. Although a public water project will likely have positive secondary economic impacts, they are not included in a state-level economic efficiency decision-making model. This is because negative secondary effects may also be present in other areas of the state because money must be withdrawn from the private sector (taxes) to finance the public project.



[a]Project construction costs include land acquisition, construction materials, permits, easements, site preparation, engineering design, construction labor, contingencies, equipment and machinery, fringe benefits associated with construction and administrative labor, administrative expenses, interest expenses during construction, and legal costs.

[b]Project use/operation costs include operation, maintenance, and replacement (OM&R) costs (e.g., wages and salaries, fringe benefits, machinery and equipment repairs and maintenance, supplies, administrative expenses, power and fuel, communications, and insurance), and user fees.

[c]Project benefits may include increases in net farm income as a result of drainage or irrigation, reduction in flood damages as a result of flood control, and increases in recreation opportunities.

Figure 12. Project Analysis Based on Economic Efficiency Criteria

Regional Economic Activity Decision-Making Model

User and owner values are not directly considered in a regional economic activity model:

User - Irrelevant

Owner - Irrelevant

Regional - What are the direct and secondary regional impacts of project implementation?

Society (state) - Only interested in comparing alternatives and regions for goals other than economic efficiency (e.g., income redistribution or regional development)

The regional economic activity model considers the direct and secondary economic benefits from a regional perspective. Secondary impacts can be divided into two groups: 1) increases in regional economic activity resulting from project services and 2) increases in regional economic activity from construction expenditures. The secondary economic impacts are estimated by using the North Dakota input-output model (Coon et al. 1984) and are measured in terms of increases in total business activity (TBA), personal income (PI), and employment in the regional economy.

Total business activity is the total value of sales that occur in the economy for a given amount of sales of final product. Personal income measures the wages and salaries received by individuals in all sectors of the economy resulting from business activity and is a part of the total business activity. Employment is the number of jobs directly or indirectly supported by the increases in TBA.

Since this decision-making model is based on a regional perspective, only "new" or "external" money (i.e., money originating from outside the region) or money no longer exported out of the region should be used in estimating secondary effects. For example, consider a reservoir created for local users. Although local entities may have paid part of the construction costs, their share may not represent "new" money to the region. In contrast, the money contributed by the state or federal government is considered "new" money to the region and is used to estimate secondary impacts.

This same logic can be used to explain increases in regional activity resulting from project services. It can be argued that money spent by local users of a recreation facility is not "new" money to the region since recreationists may be only shifting from one type of recreational activity to another (e.g., golf to fishing). These changes in participation cannot be called net gains to the region. However, if a new reservoir attracts users to the site who would have spent money at an alternate site outside the region, then this money is considered "new" and is used in assessing secondary effects. These concepts are presented in greater detail in the Regional Economic Activity Models illustrated in Appendix B.

Social Well-Being Decision-Making Model

The ultimate decision-making model considers all values taken from society's perspective:

- User - Irrelevant, only interested as a member of society
- Owner - Irrelevant, only interested as a member of society
- Regional - Irrelevant, regional development perspective is more important
- Society (state) - Consider all criteria with the ultimate decision being a function of weights placed on each criteria. For example, economic efficiency (e.g., B/C) is only one indicator. Contribution to regional development, income redistribution, and environmental quality should also be considered.

While some components of the social well-being decision-making model can be quantified (e.g., economic efficiency and regional secondary impacts), others are more difficult to measure (e.g., environmental quality and income distribution). Therefore, public decision makers must decide relative weights of components in arriving at a final decision regarding project development, modification, or rejection.

Consider an example where public investment of $100,000 would yield $120,000 in benefits in Region 1 where the average personal income is $30,000, and $100,000 would yield $110,000 in Region 2 where the average income is $15,000. The economic efficiency criteria would suggest allocating funds to Region 1. However, if income redistribution is a program objective, then investment in Region 2 may be preferable. Figure 13 illustrates how all these components of project analysis are considered in the final decision.

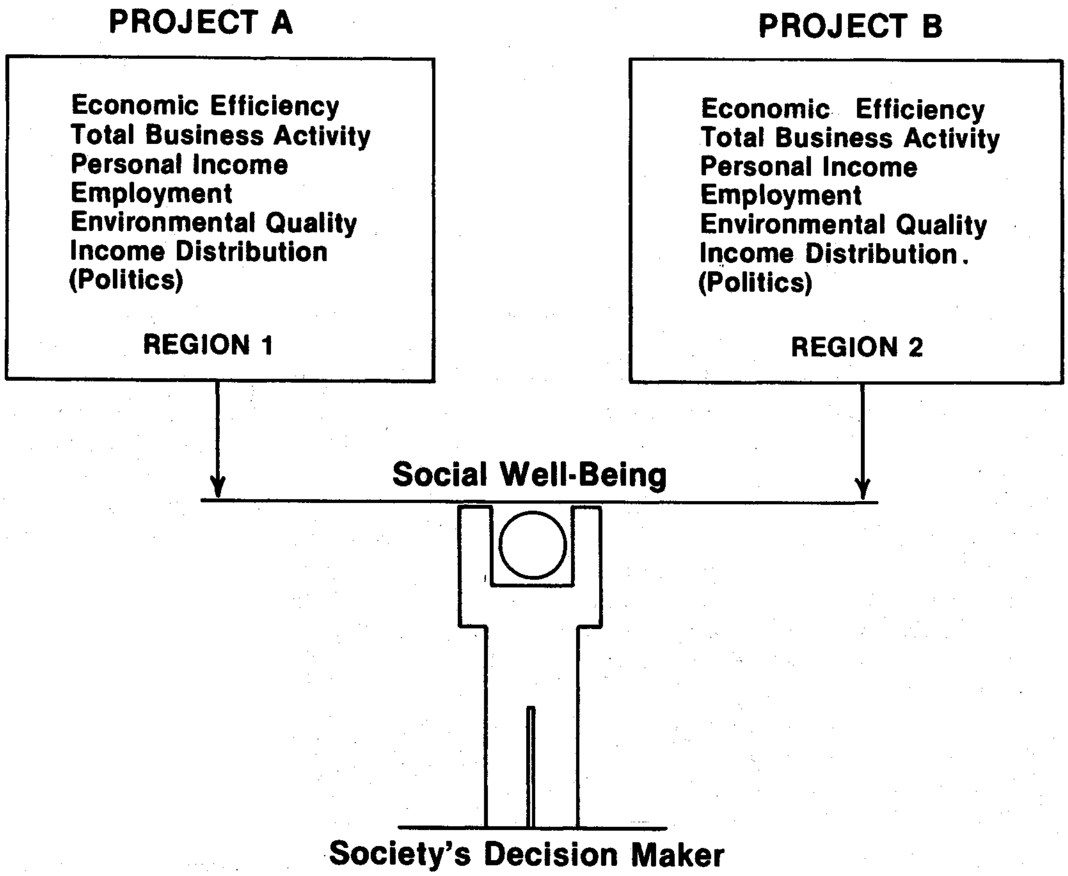


Figure 13. Elements of Decision Making in Public Sector Water Development

CASE STUDIES

Economic concepts and analytical techniques have been presented to this point with little reference to specific water projects. Two case studies are presented in which actual North Dakota water projects are evaluated to illustrate the analytical approaches. The case studies include a recreation and flood control project--Dead Colt Creek, and a drainage project--Emrick Drain.

Dead Colt Creek Dam

In April 1977, the North Dakota State Water Commission entered into an agreement with the Ransom County Water Management District to investigate the feasibility of constructing a recreational dam and associated public use area. The dam would be on Dead Colt Creek approximately four miles southeast of Lisbon, North Dakota (Figure 14).

The dam and resulting reservoir would provide local residents with opportunities for boating, fishing, picnicking, swimming, and outdoor sports. In addition, the proposed dam would retain flood waters and would therefore help reduce downstream flooding along the Sheyenne River.

Dead Colt Creek dam project was a two-phased effort. The first phase was construction of an earthen dam 80 feet high and 800 feet long. Construction began in May 1983 and was finished in December of the same year. The reservoir is about 1,000 feet wide and one and one-half miles long, and covers approximately 120 acres with an average water depth of 18 feet. The reservoir is large enough to accommodate fishing, boating, and water skiing.

Phase two of the project was development of onshore recreational areas. Recreational facilities include a fishing pier, two boat ramps, swimming beach, picnic shelters and tables, grills, playground equipment, and a camping area.

Economic Analysis

This economic analysis compares the beneficial effects with the adverse effects as they relate to the State of North Dakota and the impacted region (Figure 15). The analysis is based on a 7 percent discount rate and a 50-year project life.[3] The year of project construction, 1983, will be considered Year 0 and all values are expressed in constant 1983 dollars.

Project Costs. Monetary costs associated with the Dead Colt Creek project are (1) construction costs and (2) operation, maintenance, and replacement costs.

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[3]Seven percent was selected for illustration of the procedures and does not necessarily represent the "correct" discount rate.

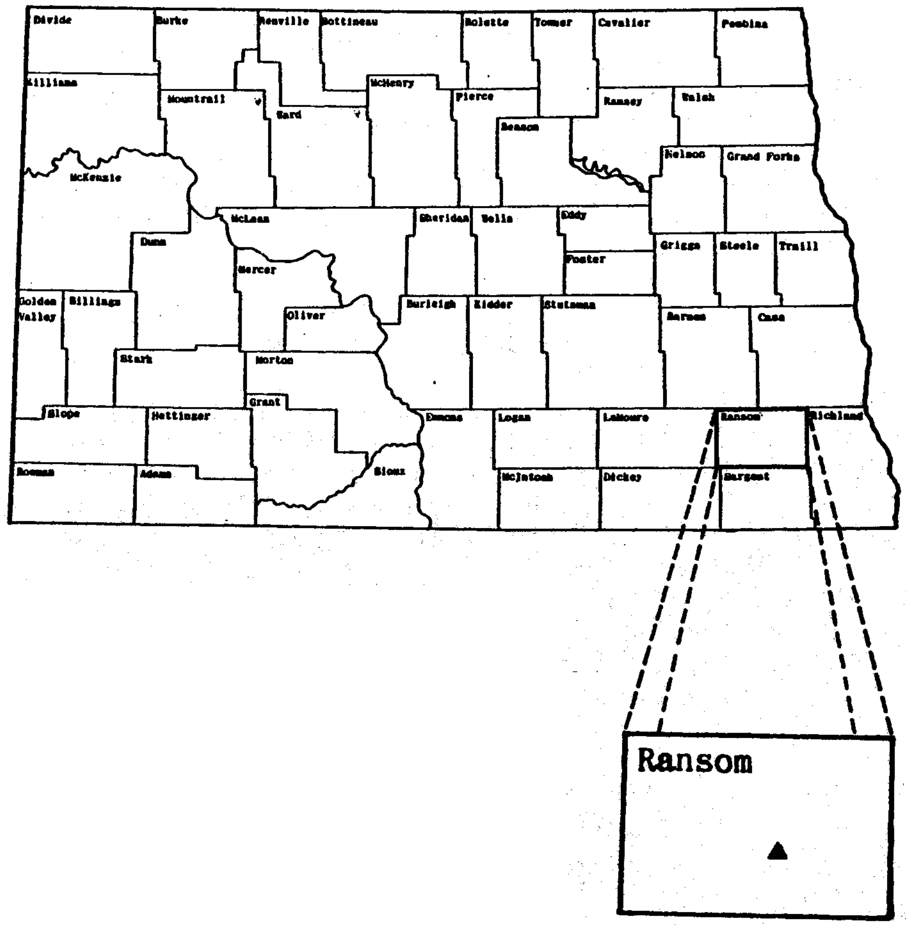

Figure 14. Location of the Dead Colt Creek Dam

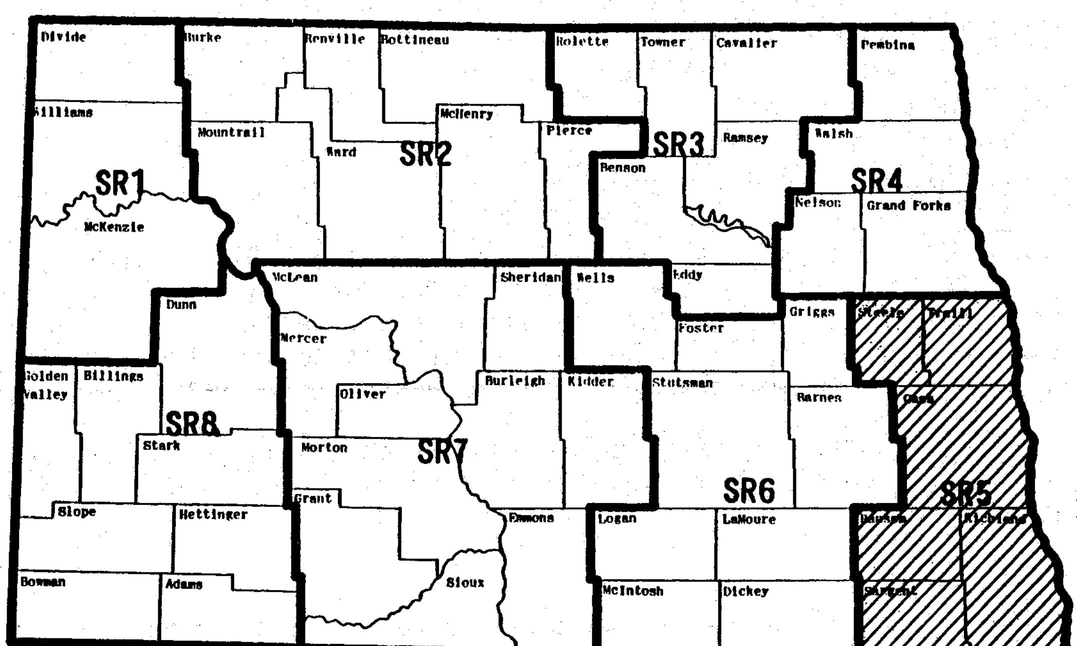

Figure 15. State Planning Region Impacted by the Dead Colt Creek Project

1. Construction Costs--Total cost for dam construction, recreation facilities, and land was $1,978,000. Cost was allocated to project participants as shown below.

Federal	$179,000
State Water Commission	519,200
State Outdoor Interagency	182,400
Red River Joint Board	500,000
Local	597,400
TOTAL	$1,978,000

2. Operation, Maintenance, and Replacement (OM&R) Costs--OM&R costs were estimated to be $10,000 per year. Present value of this stream of costs would be $130,000 over the lifetime of the project (based on the 50 year project life and 7 percent discount rate). The Ransom County Water Resource District is responsible for project operation and maintenance.

3. Summary of Costs--Total direct costs are $2,108,000 as summarized below.

Summary of Project Costs

Item	Capitalized Impact
Construction Costs	$1,978,000
OM&R Costs	130,000

Projects Benefits. Monetary benefits resulting from Dead Colt Creek Dam include (1) direct user benefits, (2) increases from project services, and (3) increases from construction expenditures.

1. Direct User Benefits--Direct user benefits include benefits accruing from recreation and flood control.

a. Direct Recreation Benefits--Recreation benefits are the increases in recreational use value for swimming, fishing, picnicking, and other recreational activities that occur as a result of the project. Two types of information are needed to estimate recreation benefits: (1) an estimate of recreation visitation to the reservoir (user days) and (2) an estimate of the net value of the recreation experience to the user.

An *ex ante* economic analysis by the North Dakota State Water Commission (1980) estimated the project would generate 58,682 recreation days in 1980, 64,385 in 2000, and 62,500 in 2020 (Table 3). The unit-day value (UDV) method was then used to estimate the value of recreation benefits.[4] A recreation day of fishing had an estimated value of $2.88. All other activities had a recreation day value of $2.61. Annual benefits were estimated to be $158,955 in 1980, $173,410 in 2000, and $168,299 in 2020.

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[4]See section on valuing recreation discussed earlier.

TABLE 3. ESTIMATED RECREATION DAYS PER ACTIVITY AS A CONSEQUENCE OF THE DEAD COLT CREEK DAM

Activity	Year 1980	2000	2020
	- - recreation days - -		
Canoeing	895	1,249	1,204
Fishing	16,695	16,465	15,876
Ice Fishing	4,770	3,407	3,285
Swimming	7,751	9,084	8,759
Camping	14,906	19,871	19,161
Picnicking	8,417	8,417	8,417
Hiking	3,280	3,280	3,280
Sailing	179	341	328
Other	1,789	2,271	2,190
Total	58,682	64,385	62,500

SOURCE: North Dakota State Water Commission, 1980.

In this analysis, recreation visitation to the reservoir is estimated by examining visitation occurring at a similar, established site--Beaver Lake State Park. This park is located on the west shore of Beaver Lake, 17 miles south of Napoleon, North Dakota. Park activities include swimming, fishing, boating, playground, picnicking, and camping. Annual visitation to Beaver Lake State Park is approximately 25,000 "composite" recreation days each year (Mittleider and Leitch 1984). A composite recreation day includes all activities associated with the water project. This figure will be used as the visitation estimate for the Dead Colt Creek project.

Recreationists visiting Beaver Lake State Park spent an average of $14.67 per day (Mittleider and Leitch 1984). Eighty-four percent of the expenditures occurred in the retail sector and 16 percent in the business and personal service sectors. In this analysis, the net value of recreation benefits is estimated to be approximately 40 percent of total recreationists' expenditures.[5] Therefore, total direct recreation benefits resulting from the Dead Colt Creek project are $146,700 per year (0.40 x $14.67/day x 25,000 days/year). The discounted value of this stream of benefits over the 50-year project life would be $2,024,600.

b. Direct Flood Control Benefits--Flood control benefits are the expected damages without the project less the actual flooding damages with the project.[6]

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[5]See section on estimating recreation benefits.

[6]See section on estimating flood control benefits.

The U.S. Army Corps of Engineers conducted an economic analysis of flood control benefits associated with Dead Colt Creek Dam. They estimated that Dead Colt Creek Dam would provide a 3 percent reduction in total Sheyenne River flood damages. This damage reduction was estimated to be worth $130,000 per year or a present value of $1,794,100 over the 50-year life of the project. The lands benefited would include about 23,400 acres of cropland and 100 acres of urban land.

2. Increases from Project Services--The secondary economic impact of the Dead Colt Creek project is the effect of increased levels of expenditures made by recreationists on the regional economy. The effects of increased expenditures were measured in terms of increases in total business activity, personal income, and employment in the regional economy.

Secondary impacts are not estimated for the flood control portion of the project since no increased levels of spending can be accurately attributed to this component. Secondary impacts are not estimated for OM&R expenditures since these costs are paid by local or regional entities.

Estimated business activity generated each year in each sector of the region's economy as a result of expenditures made by recreationists using the project are indicated in Table 4, along with employment in each sector attributable to these expenditures. Row 12 of Table 4 represents the household sector, which is the personal income generated by recreationists' expenditures. The annual increase in total business activity generated by expenditures of project users is $803,000.[7] This includes total direct expenditures of $366,750 (25,000 recreation days x $14.67/day) plus secondary effects. Present value of this stream of benefits would be $11,082,000 over the life time of the project (based on the 50-year project life and 7 percent discount rate).

The annual personal income generated in the region as a result of recreationists' expenditures is $166,000 (Table 4, Row 12). The present value of this income stream is $2,291,000.

Expenditures by project users directly and indirectly contribute to employment in various sectors of the economy. For example, even though recreationists did not spend any money directly in the professional and social service sector (Table 4, Row 11), $12,000 worth of business occurred in that sector. This amount of business activity in the professional and social service sector is enough to support the employment of one individual. All expenditures by users of the Dead Colt Creek project would support the employment of 16 people in the economy.

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[7]This is assuming that all expenditures represent new money to the region.

TABLE 4. TOTAL BUSINESS ACTIVITY AND EMPLOYMENT BY SECTOR AND PERSONAL INCOME GENERATED BY RECREATIONISTS' EXPENDITURES, DEAD COLT CREEK PROJECT (1983 DOLLARS)

Economic Sector	Total Business Activity	Employment[a]
1. Ag, Livestock	$ 29,000	b
2. Ag, Crops	11,000	b
3. Mining	1,000	b
4. Contract Construction	14,000	1
5. Transportation	4,000	b
6. Communications & Utilities	23,000	b
7. Ag Processing & Misc. Mfg.	15,000	b
8. Retail Trade	419,000	6
9. Fin., Ins., & Real Estate	24,000	b
10. Bus. & Personal Service	68,000	6
11. Prof. & Social Service	12,000	1
12. Households	166,000	--
13. Government	17,000	2
TOTAL	$803,000	16

[a]Employment in each sector was estimated using gross productivity ratios.
[b]Less than 1.0.

NOTE: Row 12, Households, represents personal income.
Annual recreationists' expenditures were $366,750. Eighty-four percent of the expenditures occur in the retail sector and 16 percent in the business and personal service sector (Mittleider and Leitch 1984).

3. Increases from Construction Expenditures--The economic impact of construction of Dead Colt Dam is the effect of an increased level of spending during the construction period on the regional economy. Effects of the additional levels of spending were measured in terms of increases in total business activity, personal income, and employment. Only funds contributed from outside the region are used to estimate these impacts. These impacts occur only once, at the time of construction, unlike the increases from project services which occur throughout the lifetime of the project.

Total construction expenditures by sources outside of the region were $880,600. These expenditures generated $2,150,000 in total business activity in the region (Table 5).[8] The personal income generated as a result of construction expenditures is $536,000 (Table 5, Row 12). These expenditures were indirectly responsible for employing 50 people in the economy. Most of this employment occurred in the construction sector.

TABLE 5. TOTAL BUSINESS ACTIVITY AND EMPLOYMENT BY SECTOR AND PERSONAL INCOME GENERATED BY CONSTRUCTION EXPENDITURES, DEAD COLT CREEK PROJECT (1983 DOLLARS)

Economic Sector	Total Business Activity	Employment[a]
1. Ag, Livestock	$ 30,000	b
2. Ag, Crops	12,000	b
3. Mining	26,000	b
4. Contract Construction	925,000	34
5. Transportation	9,000	b
6. Communications & Utilities	53,000	1
7. Ag Processing & Misc. Mfg.	18,000	b
8. Retail Trade	361,000	5
9. Fin., Ins., & Real Estate	73,000	b
10. Bus. & Personal Service	25,000	2
11. Prof. & Social Service	36,000	3
12. Households	536,000	b
13. Government	46,000	5
TOTAL	$2,150,000	50

[a]Employment in each sector was estimated using gross productivity ratios.
[b]Less than 1.0.

NOTE: Row 12, Households, represents personal income.
Construction expenditures by sources outside of the region were $880,600. These expenditures occurred in the contract construction sector.

[8]This is assuming that all construction expenditures were spent within the region.

Economic Efficiency and Regional Economic Activity Models

The economic efficiency model estimates the net economic effect on the state. The regional economic activity model measures the increase in regional economic activity as a consequence of the Dead Colt Creek project.

1. Economic Efficiency Model (EEM)--Total project benefits under the EEM are $3,818,700 (Table 6). Only the direct user benefits (i.e., recreation and flood control) are considered in this model since any positive secondary impacts in the region may be netted out by negative secondary impacts occurring in other parts of the state.

TABLE 6. ANALYSIS OF BENEFITS AND COSTS USING THE ECONOMIC EFFICIENCY MODEL, DEAD COLT CREEK PROJECT (1983 DOLLARS)

Item	Capitalized Impact
Beneficial Impacts	
Direct User Benefits	
Recreation	$2,024,600
Flood Control	1,794,100
Total Benefits	$3,818,700
Project Costs	
Construction	$1,978,000
OM&R	130,000
Total Costs	$2,108,000
Net Benefits	$1,710,700
Benefit-Cost Ratio	1.8:1

Total project costs under the EEM are $2,108,000. This includes all construction, land, and OM&R costs paid by federal, state, and local entities. The benefit-cost ratio using the EEM is 1.8:1.

2. Regional Economic Activity Model (REAM)--One interest in developing recreation projects is to contribute to general well-being. This includes the economic health of communities in addition to providing increased opportunities for citizens to participate in recreation activities. Therefore, another method which can be used to evaluate water projects is to compare the increases in regional economic activity that would be associated with alternative projects. Total business activity (TBA)

generated by the Dead Colt Creek project is $13,232,000 (Table 7). This includes direct expenditures plus associated secondary impacts. Total personal income (PI) (which is a part of total business activity) generated over the life time of the project is $2,827,000.

TABLE 7. INCREASES IN REGIONAL ECONOMIC ACTIVITY, DEAD COLT CREEK PROJECT (PRESENT VALUE IN 1983 DOLLARS)

Item	Capitalized Impact TBA	Capitalized Impact PI
Increases from Project Services	$11,082,000	$2,291,000
Increases from Construction Expenditures	2,150,000	536,000
Totals	$13,232,000	$2,827,000

Emrick Legal Drain

The Emrick watershed is in the Drift Prairie region of Wells County, North Dakota. The area economy is structured around agriculture. Most of the land is productive farmland, producing small grains and row crops. Flood problems have been evident for many years within this watershed and poor surface drainage has hindered farming operations. The Emrick Drain project was designed to provide an outlet for runoff from the 21-square mile Emrick watershed (Figure 16).

Economic Analysis

This economic analysis compares the beneficial effects with the adverse effects as they relate to North Dakota and the impacted region as a consequence of Emrick Drain (Figure 17). The analysis is based on a 7 percent discount rate and a 50-year project life. The year of project construction, 1983, will be considered year 0 and all values are expressed in constant 1983 dollars.

Project Costs. Monetary costs associated with the Emrick Drain are (1) construction costs and (2) operation, maintenance, and replacement costs.

1. Construction Costs--Construction cost of the main project features was $170,000. This cost was allocated to project participants as shown below.

State Water Commission	$ 46,200
Local (by assessment)	123,800
TOTAL	$170,000

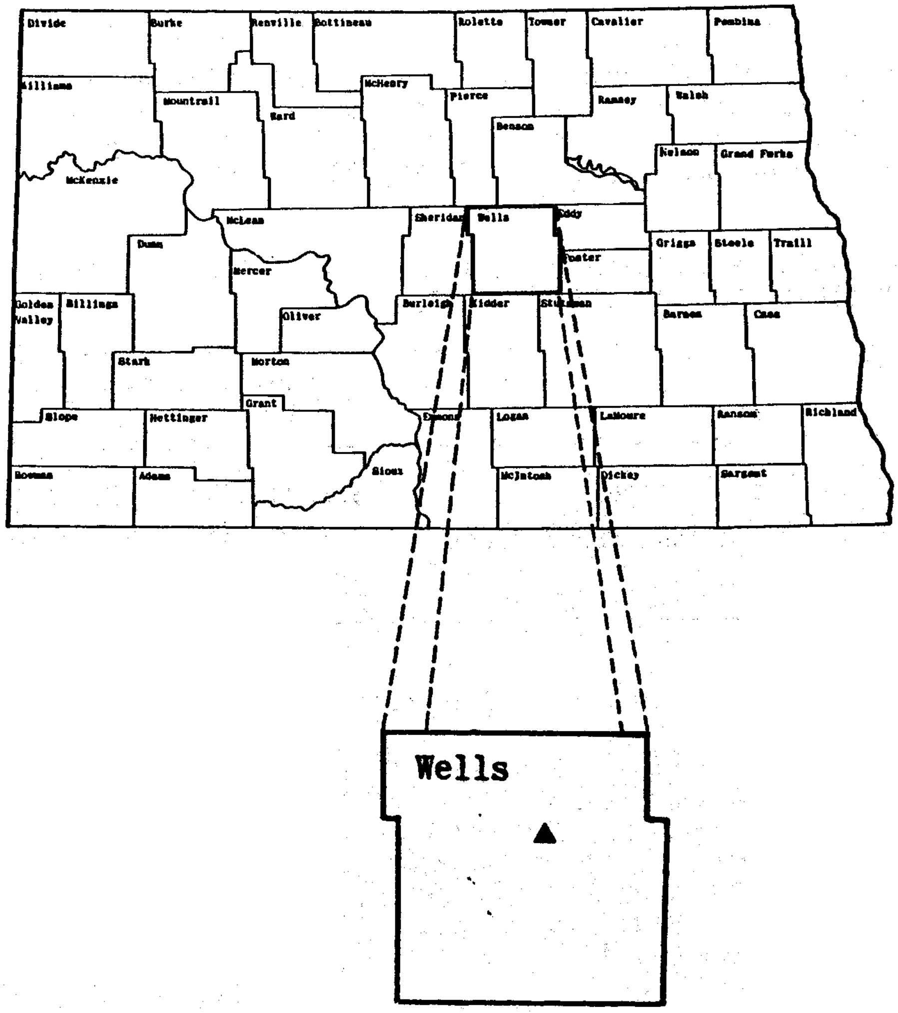

Figure 16. Location of the Emrick Legal Drain

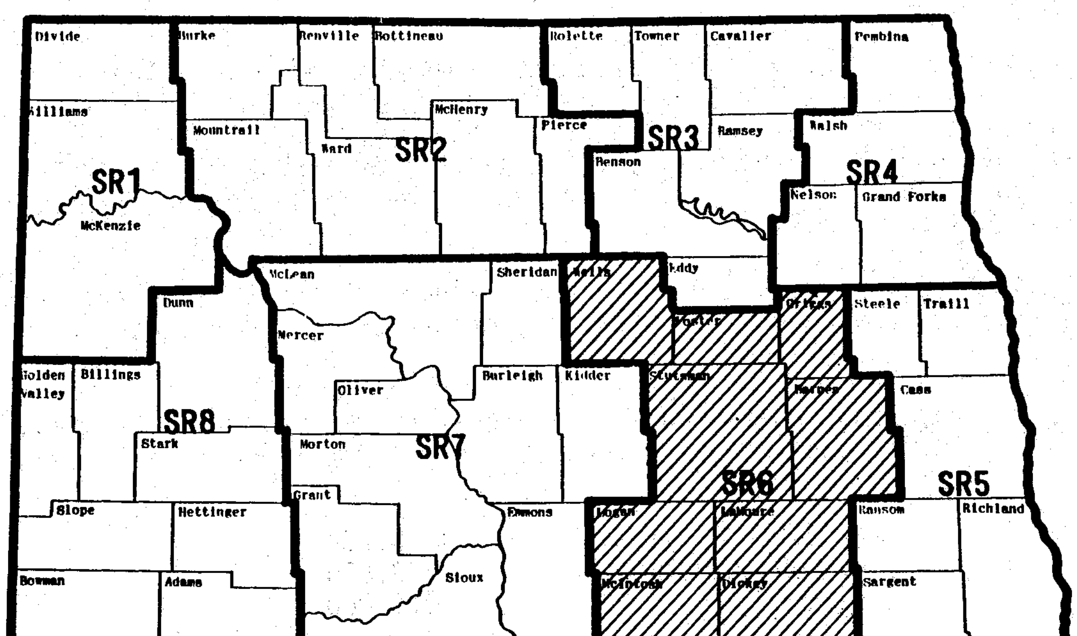

Figure 17. State Planning Region Impacted by the Emrick Legal Drain

2. Operation, Maintenance, and Replacement Costs (OM&R)--Periodic maintenance of drainage ditches is required to maintain their function and to extend their useful life. Estimates of the cost of ditch maintenance range from 3 percent of the initial cost per year assuming a 15-year life (U.S. Soil Conservation Service 1978) to one-third of the original cost every seven years (Goldstein 1967). OM&R costs for the Emrick Drain were assumed to be $8,000 per year for the life of the project (50 years). It is assumed that these costs will be paid by landowners benefiting from project features.

3. Summary of Costs--Total direct costs are $280,400 as summarized below.

Summary of Project Costs

Item	Capitalized Impact
Project Construction Costs	$170,000
OM&R Cost	110,400

Beneficial Impacts. Project monetary impacts are (1) direct user benefits, (2) increases from project services, and (3) increases from construction expenditures.

1. Direct User Benefits--Direct user benefits are the increases in net farm income due to drainage under future conditions with the project as compared to without the project. Net farm income without the drainage project is projected by estimating the expected cropping pattern in the absence of any drainage facilities. Farm budgets, yields, and net farm income are then developed for each crop in the cropping pattern. This same procedure is used to estimate net farm income with the drainage project. Future cropping patterns, farm budgets, and yields are developed for the acreages to be drained.

A damage-benefit analysis was conducted in 1977 by the U.S. Soil Conservation Service for a proposed drainage project in Rocky Run Watershed (North Dakota State Water Commission 1977). The Emrick Watershed, which is part of the larger Rocky Run Watershed, was included in that analysis. A sample of watershed residents were interviewed to estimate the amount of land that is frequently subject to flooding and changes in crop yields if the project were implemented. Net return to drainage per composite acre was estimated to be $38 (1976 dollars) (Table 8). Production costs would increase $5 (1976 dollars) per acre served.[8] If 1,000 acres were effectively served as a consequence of the project, annual drainage benefits would be $60,000 (1983 dollars) ($60.00/acre x 1,000 acres).[9] The discounted value of this stream of benefits is $828,000.

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[8]Additional information on agricultural land drainage costs and returns are provided in a study by Leitch and Kerestes (1981).

[9]The net return per composite acre of $38 (1976 dollars) was indexed to $60 (1983 dollars).

TABLE 8. ROCKY RUN WATERSHED: INCOME STATEMENT FOR COMPOSITE ACRE OF DRAINED LAND (1976 DOLLARS)

Crop	Yield (Projected)	Price	Gross Return Per Acre	Production Costs	Net Return Per Acre	% Comp. Acre	Net Comp. Return
Wheat	48.2 bu.	$ 4.19	$202	$95	$107	41.4	$44.30
Barley	63.6	2.58	164	74	90	6.9	6.21
Flax	17.2	6.46	111	54	57	5.3	3.02
Oats	60.0	1.32	79	40	39	5.1	1.99
Hay (all)	2.0 tons	37.04	74	33	41	11.9	4.88
Sunflower	1,248 lbs.	10.00	125	75	50	4.7	2.35
Fallow						24.7	
TOTAL						100.0	$62.75
Difference	(with project)	$62.75					
	(without project)	$24.92					
		$37.83					

SOURCE: North Dakota State Water Commission, 1977.

NOTE: The Farm Management Planning Guides prepared by the Cooperative Extension Service, North Dakota State University, Fargo, are good sources for this type of data for future analyses.

2. Increase from Project Services--The secondary economic impact of Emrick Drain is the effect of increased levels of spending for production inputs, project OM&R costs, and increased net returns of landowners on the regional economy measured in terms of increases in TBA, PI, and employment.

The annual increase in spending for production inputs was $8,000 ($8/acre x 1,000 acres), and $8,000 was spent for project OM&R costs.[10] Annual increase in net farm income (less OM&R costs) is $52,000. The estimated total business activity generated each year in each sector of the state's economy as a result of these increases is indicated in Table 9.[11]

TABLE 9. TOTAL BUSINESS ACTIVITY AND EMPLOYMENT BY SECTOR AND PERSONAL INCOME GENERATED BY PROJECT SERVICES OF THE EMRICK DRAIN (1983 DOLLARS)

Economic Sector	Total Business Activity	Employment[a]
1. Ag, Livestock	$ 4,000	b
2. Ag, Crops	2,000	b
3. Mining	0	b
4. Contract Construction	7,000	b
5. Transportation	1,000	b
6. Communications & Util.	6,000	b
7. Ag Processing & Misc. Mfg.	2,000	b
8. Retail Trade	52,000	b
9. Fin., Ins., & Real Estate	11,000	b
10. Bus. & Personal Service	6,000	b
11. Prof. & Social Service	6,000	b
12. Households	95,000	--
13. Government	6,000	b
TOTAL	$198,000	>0

[a]Employment in each sector was estimated using gross productivity ratios.
[b]Less than 1.0.

NOTE: Row 12, Households, represents personal income.

3. Increases from Construction Expenditures--The secondary economic impact of construction of the Emrick Drain is the effect of the increased level of spending during construction in Region 6 measured in terms of increases in TBA, PI, and employment. Total construction expenditures by

[10]The increase in spending for production inputs of $5 per acre (1976 dollars) was indexed to $8 per acre (1983 dollars).

[11]This is assuming that these expenditures were spent within the region.

sources outside the region were $46,200. These expenditures generated $112,000 in total business activity during the construction period (Table 10).[12]

TABLE 10. TOTAL BUSINESS ACTIVITY AND EMPLOYMENT BY SECTOR AND PERSONAL INCOME GENERATED BY CONSTRUCTION EXPENDITURES, EMRICK DRAIN (1983 DOLLARS)

Economic Sector	Total Business Activity	Employment[a]
1. Ag, Livestock	$ 2,000	b
2. Ag, Crops	1,000	b
3. Mining	1,000	b
4. Contract Construction	48,000	1
5. Transportation	0	b
6. Communications & Util.	3,000	b
7. Ag Processing & Misc. Mfg.	1,000	b
8. Retail Trade	19,000	b
9. Fin., Ins., & Real Estate	4,000	b
10. Bus. & Personal Service	1,000	b
11. Prof. & Social Service	2,000	b
12. Households	28,000	--
13. Government	2,000	b
Totals	$112,000	>1

[a]Employment in each sector was estimated using gross productivity ratios.
[b]Less than 1.0.

NOTE: Row 12, Households, represents personal income.
Construction expenditures by sources outside the region were $46,200. These expenditures occurred in the contract construction sector.

Construction expenditures generated $28,000 in personal income (Table 10, Row 12) and were responsible for the direct or secondary employment of at least one person during the construction period.

Economic Efficiency and Regional Economic Activity Models

The economic efficiency model estimates net economic effects on the state. The regional economic activity model measures the increase in regional economic activity as a consequence of Emrick Drain.

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[12]This is assuming that all construction expenditures were spent within the region.

1. Economic Efficiency Model (EEM)--Total project benefits using the EEM are $828,000 and total project costs are $280,400 (Table 11). The resulting benefit-cost ratio is 3.0:1.

TABLE 11. ANALYSIS OF BENEFITS AND COSTS USING THE ECONOMIC EFFICIENCY MODEL, EMRICK DRAIN (1983 DOLLARS)

Item	Capitalized Impact
Beneficial Impacts	
Direct User Benefits	
Increase in Net Farm Income	$828,000
Project Costs	
Construction	$170,000
OM&R	110,400
Total Costs	$280,400
Net Benefits	$547,600
Benefit-Cost Ratio	3.0:1

2. Regional Economic Activity Model (REAM)--Total business activity generated by the Emrick Drain is $2,845,000 (Table 12). This includes direct expenditures plus associated secondary impacts. Total personal income generated over the life time of the project is $1,339,000.

TABLE 12. INCREASES IN REGIONAL ECONOMIC ACTIVITY, EMRICK DRAIN (PRESENT VALUE IN 1983 DOLLARS)

Item	Capitalized Impact TBA	Capitalized Impact PI
Increases from Project Services	$2,733,000	$1,311,000
Increases from Construction Expenditures	112,000	28,000
TOTAL	$2,845,000	$1,339,000

EX POST ANALYSES

Benefit-cost analysis has long been used as a primary tool for planning and justifying water projects. However, after the project is established, almost no record is kept of actual benefits and costs that accrue so no comparison can be made with planning expectations. When *ex post* analyses have been conducted, the results have been less than encouraging.

An *ex post* analysis of the Pick-Sloan Missouri Basin Program indicated that due to uncertainties and imperfections, benefit-cost analysis and long range planning are of questionable utility and are very misleading as measures for program justification (Wilkinson 1975). Because benefit-cost estimating procedures remain so imperfect, a wide range of calculated values is possible; however, it appeared that flood control and electric power program benefits far exceeded plan expectations, while those for irrigation and navigation programs fell short. The *ex post* analysis also revealed that external forces had radically altered the original plans.

Ex post analyses should become an integral part of public sector water development. Such analyses can help strengthen future planning efforts and can establish a more clear-cut accountability to the public. The decision to do an *ex post* analysis should be made before a project is built or program is started. Information needed can be identified, and procedures for collection established.[13]

A problem with *ex post* analyses is that most water resource projects are long-lived investments. An analysis conducted only 10 years after a project is implemented may capture only a fifth of the benefits, and estimates must still be made of future outputs. However, it would be hard to argue that future planning efforts could not be improved with even this type of limited post-project analysis.

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[13] See Haveman (1971) for methodology of *ex post* analyses of water resource projects.

CONCLUSION AND IMPLICATIONS

We have presented some objective guidelines for evaluating state-level water resource development projects. We conclude by re-emphasizing an important point made at the beginning of this report: project economic analysis is only one step in the comprehensive planning and decision-making process.

The procedures and guidelines in the report were aimed, to a large extent, at project-related impacts that could be quantified and expressed in economic terms. Clearly, economic efficiency and secondary economic impacts are important components of public sector decision making. However, if nonquantifiable impacts are not addressed, a simplistic, inaccurate rule would result in which anything which produces the greatest number of visitors and/or greatest expenditures is considered the best. Although these items are important, the analyst must also be concerned with the incidence of these impacts, with the effects on other social values, the effects on project users (user satisfaction), and with the impacts on the environment.

The broad aim of water resource development is to increase social welfare. Project analysis can reveal parts of the overall picture by organizing and utilizing technical and economic information about proposed public sector projects. It should not be expected, however, to do more than it can reasonably do. That is, it cannot be expected to take the politics out of public decisions by replacing them with a single-number ratio meant to represent all aspects of social welfare.

Even though many years have been spent trying to improve analytical procedures, no one has succeeded in making it totally impartial or indisputable. Objective project analyses are complicated by both disputes over basic assumptions and widely divergent choices concerning difficult issues, such as discount rates and the value of wildlife. Therefore, public participation must continue to play an important role in the ultimate decisions.

APPENDIX A

Present Value Tables

APPENDIX TABLE A1. PRESENT VALUE OF $1

Year (n)	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091	0.9009	0.8929	0.8850	0.8772
2	0.9803	0.9612	0.9426	0.9246	0.9070	0.8900	0.8734	0.8573	0.8417	0.8264	0.8116	0.7972	0.7831	0.7695
3	0.9706	0.9423	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938	0.7722	0.7513	0.7312	0.7118	0.6931	0.6750
4	0.9610	0.9238	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350	0.7084	0.6830	0.6587	0.6355	0.6133	0.5921
5	0.9515	0.9057	0.8626	0.8219	0.7835	0.7473	0.7130	0.6806	0.6499	0.6209	0.5935	0.5674	0.5428	0.5194
6	0.9420	0.8880	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302	0.5963	0.5645	0.5346	0.5066	0.4803	0.4556
7	0.9327	0.8706	0.8131	0.7599	0.7107	0.6651	0.6228	0.5835	0.5470	0.5132	0.4817	0.4523	0.4251	0.3996
8	0.9235	0.8535	0.7894	0.7307	0.6768	0.6274	0.5820	0.5403	0.5019	0.4665	0.4339	0.4039	0.3762	0.3506
9	0.9143	0.8368	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002	0.4604	0.4241	0.3909	0.3606	0.3329	0.3075
10	0.9053	0.8203	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632	0.4224	0.3855	0.3522	0.3220	0.2946	0.2697
11	0.8963	0.8043	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289	0.3875	0.3505	0.3173	0.2875	0.2607	0.2366
12	0.8874	0.7885	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971	0.3555	0.3186	0.2858	0.2567	0.2307	0.2076
13	0.8787	0.7730	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677	0.3262	0.2897	0.2575	0.2292	0.2042	0.1821
14	0.8700	0.7579	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405	0.2992	0.2633	0.2320	0.2046	0.1807	0.1597
15	0.8613	0.7430	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152	0.2745	0.2394	0.2090	0.1827	0.1599	0.1401
16	0.8528	0.7284	0.6232	0.5339	0.4581	0.3936	0.3387	0.2919	0.2519	0.2176	0.1883	0.1631	0.1415	0.1229
17	0.8444	0.7142	0.6050	0.5134	0.4363	0.3714	0.3166	0.2703	0.2311	0.1978	0.1696	0.1456	0.1252	0.1078
18	0.8360	0.7002	0.5874	0.4936	0.4155	0.3503	0.2959	0.2502	0.2120	0.1799	0.1528	0.1300	0.1108	0.0946
19	0.8277	0.6864	0.5703	0.4746	0.3957	0.3305	0.2765	0.2317	0.1945	0.1635	0.1377	0.1161	0.0981	0.0829
20	0.8195	0.6730	0.5537	0.4564	0.3769	0.3118	0.2584	0.2145	0.1784	0.1486	0.1240	0.1037	0.0868	0.0728
21	0.8114	0.6598	0.5375	0.4388	0.3589	0.2942	0.2415	0.1987	0.1637	0.1351	0.1117	0.0926	0.0768	0.0638
22	0.8034	0.6468	0.5219	0.4220	0.3418	0.2775	0.2257	0.1839	0.1502	0.1228	0.1007	0.0826	0.0680	0.0560
23	0.7954	0.6342	0.5067	0.4057	0.3256	0.2618	0.2109	0.1703	0.1378	0.1117	0.0907	0.0738	0.0601	0.0491
24	0.7876	0.6217	0.4919	0.3901	0.3101	0.2470	0.1971	0.1577	0.1264	0.1015	0.0817	0.0659	0.0532	0.0431
25	0.7798	0.6095	0.4776	0.3751	0.2953	0.2330	0.1842	0.1460	0.1160	0.0923	0.0736	0.0588	0.0471	0.0378
26	0.7720	0.5976	0.4637	0.3607	0.2812	0.2198	0.1722	0.1352	0.1064	0.0839	0.0663	0.0525	0.0417	0.0331
27	0.7644	0.5859	0.4502	0.3468	0.2678	0.2074	0.1609	0.1252	0.0976	0.0763	0.0597	0.0469	0.0369	0.0291
28	0.7568	0.5744	0.4371	0.3335	0.2551	0.1956	0.1504	0.1159	0.0895	0.0693	0.0538	0.0419	0.0326	0.0255
29	0.7493	0.5631	0.4243	0.3207	0.2429	0.1846	0.1406	0.1073	0.0822	0.0630	0.0485	0.0374	0.0289	0.0224
30	0.7419	0.5521	0.4120	0.3083	0.2314	0.1741	0.1314	0.0994	0.0754	0.0573	0.0437	0.0334	0.0256	0.0196
35	0.7059	0.5000	0.3554	0.2534	0.1813	0.1301	0.0937	0.0676	0.0490	0.0356	0.0259	0.0189	0.0139	0.0102
40	0.6717	0.4529	0.3066	0.2083	0.1420	0.0972	0.0668	0.0460	0.0318	0.0221	0.0154	0.0107	0.0075	0.0053
45	0.6391	0.4102	0.2644	0.1712	0.1113	0.0727	0.0476	0.0313	0.0207	0.0137	0.0091	0.0061	0.0041	0.0027
50	0.6080	0.3715	0.2281	0.1407	0.0872	0.0543	0.0339	0.0213	0.0134	0.0085	0.0054	0.0035	0.0022	0.0014

SOURCE: Richard D. Aplin and George L. Casler. 1973. Capital Investment Analysis, Grid, Inc., Columbus, Ohio.

APPENDIX TABLE A2. PRESENT VALUE OF $1 RECEIVED ANNUALLY AT THE END OF EACH YEAR FOR N YEARS

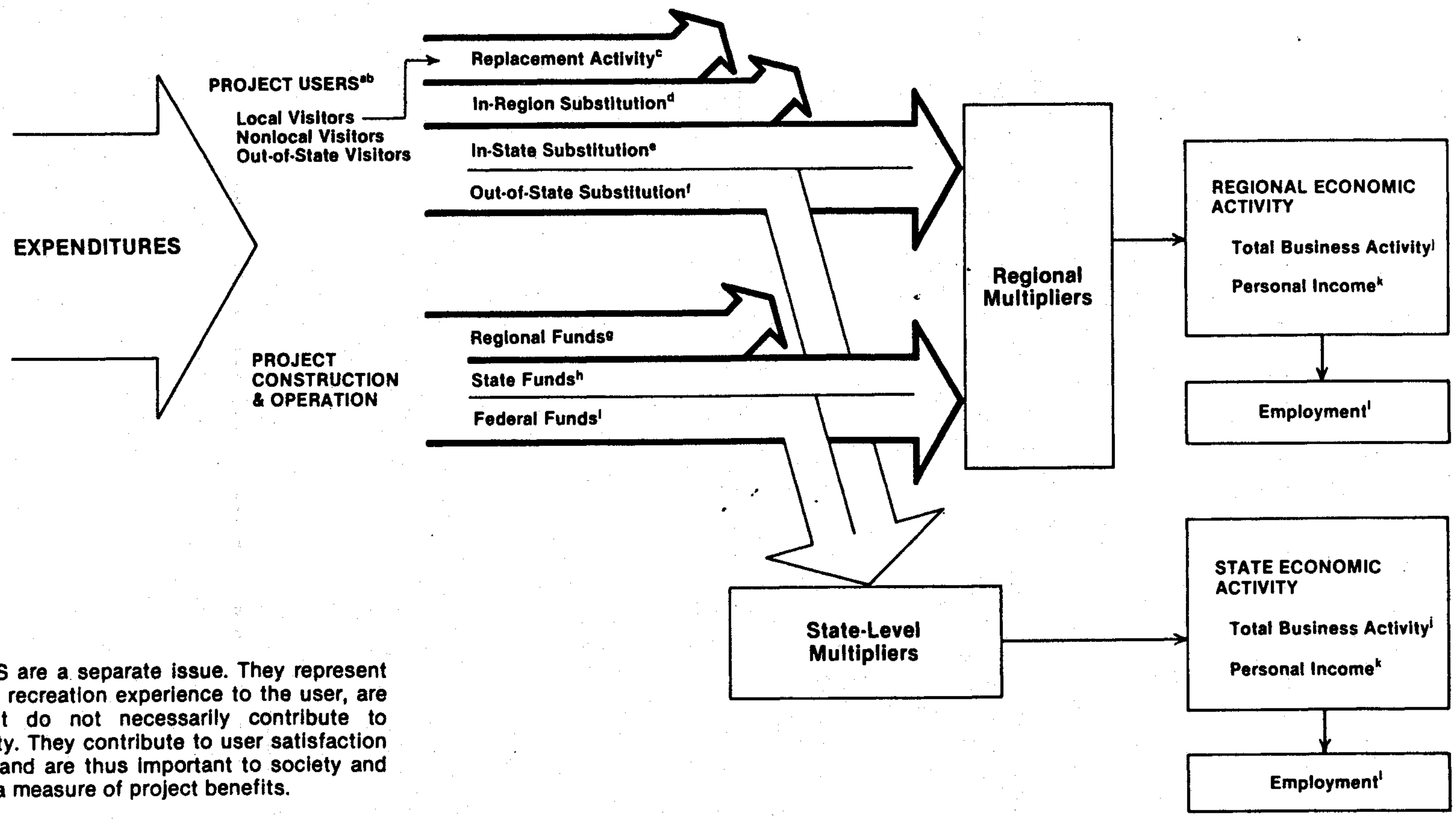
Year (n)	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091	0.9009	0.8929	0.8850	0.8772
2	1.9704	1.9416	1.9135	1.8861	1.8594	1.8334	1.8080	1.7833	1.7591	1.7355	1.7125	1.6901	1.6681	1.6467
3	2.9410	2.8839	2.8286	2.7751	2.7232	2.6730	2.6243	2.5771	2.5313	2.4869	2.4437	2.4018	2.3612	2.3216
4	3.9020	3.8077	3.7171	3.6299	3.5460	3.4651	3.3872	3.3121	3.2397	3.1699	3.1024	3.0374	2.9745	2.9137
5	4.8534	4.7135	4.5797	4.4518	4.3295	4.2124	4.1002	3.9927	3.8897	3.7908	3.6959	3.6048	3.5172	3.4331
6	5.7955	5.6014	5.4172	5.2421	5.0757	4.9173	4.7665	4.6229	4.4859	4.3553	4.2305	4.1114	3.9976	3.8887
7	6.7282	6.4720	6.2303	6.0021	5.7864	5.5824	5.3893	5.2064	5.0330	4.8684	4.7122	4.5638	4.4226	4.2883
8	7.6517	7.3255	7.0197	6.7327	6.4632	6.2098	5.9713	5.7466	5.5348	5.3349	5.1461	4.9676	4.7988	4.6389
9	8.5660	8.1622	7.7861	7.4353	7.1078	6.8017	6.5152	6.2469	5.9952	5.7590	5.5370	5.3282	5.1317	4.9464
10	9.4713	8.9826	8.5302	8.1109	7.7217	7.3601	7.0236	6.7101	6.4177	6.1446	5.8892	5.6502	5.4262	5.2161
11	10.3676	9.7868	9.2526	8.7605	8.3064	7.8869	7.4987	7.1390	6.8052	6.4951	6.2065	5.9377	5.6869	5.4527
12	11.2551	10.5753	0.9540	9.3851	8.8633	8.3838	7.9427	7.5361	7.1607	6.8137	6.4924	6.1944	5.9176	5.6603
13	12.1337	11.3484	10.6350	9.9856	9.3936	8.8527	8.3576	7.9038	7.4869	7.1034	6.7499	6.4236	6.1218	5.8424
14	13.0037	12.1062	11.2961	10.5631	9.8986	9.2950	8.7455	8.2442	7.7862	7.3667	6.9819	6.6282	6.3025	6.0021
15	13.8651	12.8493	11.9379	11.1184	10.3797	9.7122	9.1079	8.5595	9.0607	7.6061	7.1909	6.8109	6.4624	6.1422
16	14.7179	13.5777	12.5611	11.6523	10.8378	10.1059	9.4466	8.8514	8.3126	7.8237	7.3792	6.9740	6.6039	6.2651
17	15.5623	14.2919	13.1661	12.1657	11.2741	10.4773	9.7632	9.1216	8.5436	8.0216	7.5488	7.1196	6.7291	6.3729
18	16.3983	14.9920	13.7535	12.6593	11.6896	10.8276	10.0591	9.3719	8.7556	8.2014	7.7016	7.2497	6.8399	6.4674
19	17.2260	15.6785	14.3238	13.1339	12.0853	11.1581	10.3356	9.6036	8.9501	8.3649	7.8393	7.3658	6.9380	6.5504
20	18.0456	16.3514	14.8775	13.5903	12.4622	11.4699	10.5940	9.8181	9.1286	8.5136	7.9633	7.4694	7.0248	6.6231
21	18.8570	17.0112	15.4150	14.0292	12.8212	11.7641	10.8355	10.0168	9.2922	8.6487	8.0751	7.5620	7.1016	6.6870
22	19.6604	17.6580	15.9369	14.4511	13.1630	12.0416	11.0612	10.2007	9.4424	8.7715	8.1757	7.6446	7.1695	6.7429
23	20.4558	18.2922	16.4436	14.8568	13.4886	12.3034	11.2722	10.3711	9.5802	8.8832	8.2664	7.7184	7.2297	6.7921
24	21.2434	18.9139	16.9355	15.2470	13.7986	12.5504	11.4693	10.5288	8.7066	8.9847	8.3481	7.7843	7.2829	6.8351
25	22.0232	19.5235	17.4131	15.6221	14.0939	12.7834	11.6536	10.6748	9.8226	9.0770	8.4217	7.8431	7.3300	6.8729
26	22.7952	20.1210	17.8768	15.9828	14.3752	13.0032	11.8258	10.8100	9.9290	9.1610	8.4881	7.8957	7.3717	6.9061
27	23.5596	20.7069	18.3270	16.3296	14.6430	13.2105	11.9867	10.9352	10.0266	9.2372	8.5478	7.9426	7.4086	6.9352
28	24.3164	21.2813	18.7641	16.6631	14.8981	13.4062	12.1371	11.0511	10.1161	9.3066	8.6016	7.9844	7.4412	6.9607
29	25.0658	21.8444	19.1885	16.9837	15.1411	13.5907	12.2777	11.1584	10.1983	9.3696	8.6501	8.0218	7.4701	6.9830
30	25.8077	22.3965	19.6004	17.2920	15.3725	13.7648	12.4090	11.2578	10.2737	9.4269	8.6938	8.0552	7.4957	7.0027
31	26.5423	22.9377	20.0004	17.5885	15.5928	13.9291	12.5318	11.3498	10.3428	9.4790	8.7332	8.0850	7.5183	7.0199
32	27.2696	23.4683	20.3888	17.8736	15.8027	14.0840	12.6466	11.4350	10.4062	9.5264	8.7686	8.1116	7.5383	7.0350
33	27.9897	23.9886	20.7658	18.1476	16.0025	14.2302	12.7538	11.5139	10.4644	9.5694	8.8005	8.1354	7.5560	7.0482
34	28.7027	24.4986	21.1318	18.4112	16.1929	14.3681	12.8540	11.5869	10.5178	9.6086	8.8293	8.1566	7.5717	7.0599
35	29.4086	24.9986	21.4872	18.6646	16.3742	14.4982	12.9477	11.6546	10.5668	9.6442	8.8552	8.1755	7.5856	7.0700
40	32.8347	27.3555	23.1148	19.7928	17.1591	15.0463	13.3317	11.9246	10.7574	9.7791	8.9511	8.2438	7.6344	7.1050
45	36.0945	29.4902	24.5187	20.7200	17.7741	15.4558	13.6055	12.1084	10.8812	9.8628	9.0079	8.2825	7.6609	7.1232
50	39.1961	31.4236	25.7298	21.4822	18.2559	15.7619	13.8007	12.2335	10.9617	9.9148	9.0417	8.3045	7.6752	7.1327

SOURCE: Richard D. Aplin and George L. Casler. 1973. Capital Investment Analysis, Grid, Inc., Columbus, Ohio.

APPENDIX B

Regional Economic Activity Models

REGIONAL ECONOMIC ACTIVITY MODEL
(REAM)
State Water Projects-Recreation



[a] USER VALUES are a separate issue. They represent the value of the recreation experience to the user, are measurable, but do not necessarily contribute to economic activity. They contribute to user satisfaction and well-being, and are thus important to society and can be used as a measure of project benefits.

[b] See the accompanying figure for examples of the three visitor types.

[c] REPLACEMENT ACTIVITY-Local project users merely shift expenditures from an alternative activity (e.g. bowling) to a new activity (e.g. fishing). The addition to regional economic activity is only the net increase over the former activity.

[d] IN-REGION SUBSTITUTION-The new project is a substitute for another site in the same region. There is no net gain to the region or the state.

[e] IN-STATE SUBSTITUTION-The new project is a substitute for a site in another region. This is a gain to one region but a loss to the other and thus does not

[f] OUT-OF-STATE SUBSTITUTION-The new project is a substitute for a site in another state. This is a net gain for the region and the state. All activity by out-of-state visitors is added economic activity to the region and state.

[g] REGIONAL FUNDS-Local funds originating from within the region represent no added economic activity for the region or the state, only a transfer from one entity to another.

[h] STATE FUNDS-State appropriations which are spent in the region are a gain to the region but no gain to the

[i] FEDERAL FUNDS-Funds contributed by sources outside the state which are spent in the region are a net gain to the state and region.

[j] TOTAL BUSINESS ACTIVITY-A measure of total business volume, tracing a purchase/sale through the regional economy.

[k] PERSONAL INCOME-The component of total business activity that goes to households.

[l] EMPLOYMENT-The number of jobs supported as a

Project Visitation Scenarios for REAM

Individual "a" goes to Site B within Region 3 instead of another activity in Region 3—this is a replacement activity which only adds to regional economic activity by the net increase over the former activity. No significant change in state-level economic activity.

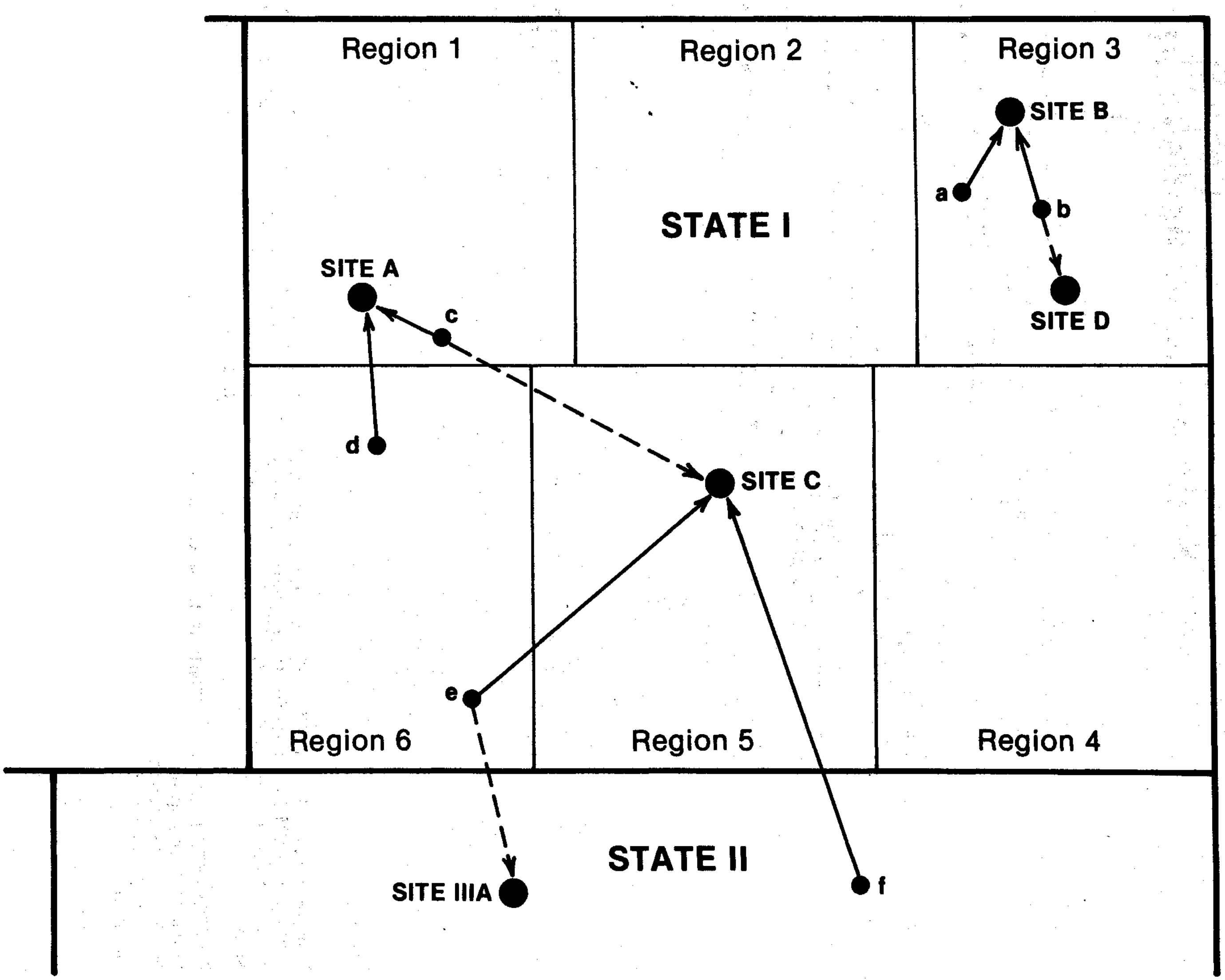
Individual "b" goes to site B within Region 3 instead of going to site D within the same region. This represents in-region substitution and is no gain to the region or state.

Individual "c" visits site A within Region 1 instead of site C in Region 5. This represents in-state substitution. The activity is a gain to Region 1 but a loss to Region 5 and no net gain to the state.

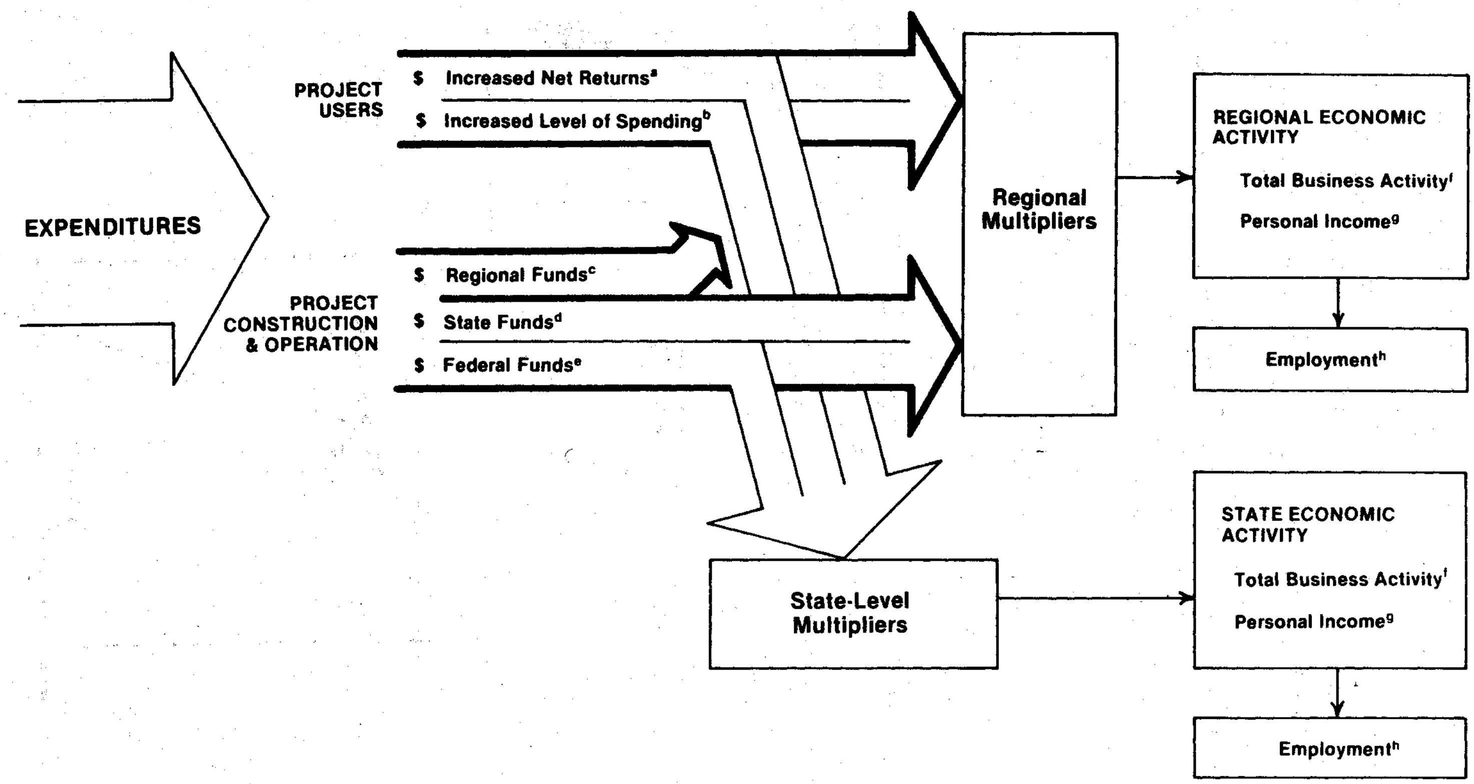
Individual "d" visits site A in neighboring Region 1. This is additional economic activity to Region 1 but a loss to Region 6 and no change to the state.

Individual "e" visits site C within Region 5 instead of site IIIA in a neighboring state. This represents new economic activity to the region and state.

Individual "f" from outside the state visits site C in Region 5. This represents new economic activity to Region 5 and State I.



REGIONAL ECONOMIC ACTIVITY MODEL (REAM)
State Water Projects-Irrigation & Drainage



[a] INCREASED NET RETURNS-The increased net returns (less OM & R costs) due to irrigation or drainage represents added economic activity to the region and state.

[b] INCREASED LEVEL OF SPENDING-Increases in the levels of spending for production inputs and OM & R represents new economic activity to the region and state where the spending occurs (assuming the increases in gross returns are sufficient to cover these expeditures).

[c] REGIONAL FUNDS-Local Funds originating from within the region represent no added economic activity to the region or the state, only a transfer from one entity to another.

[d] STATE FUNDS-State appropriations which are spent in the region are a net gain to the region but no gain to the state.

[e] FEDERAL FUNDS-Funds contributed by sources outside the state are added economic activity to the region in which they are spent and a gain to the state.

[f] TOTAL BUSINESS ACTIVITY-A measure of total business volume, tracing a purchase/sale through the regional economy.

[g] PERSONAL INCOME-The component of total business activity that goes to households.

[h] EMPLOYMENT-The number of jobs supported as a result of the total business activity.

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