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Technical Bulletin 295—1974

Economics of Small Watershed Planning in Minnesota

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PREFACE

This bulletin reports a part of the research completed under a cooperative research project of the University of Minnesota Agricultural Experiment Station and the Economic Research Service of the U.S. Department of Agriculture—An Analysis of Public Investments in Natural Resources Within Minnesota. Acknowledgments are due to Lee R. Martin, Jerome W. Hammond, and Philip M. Raup who reviewed the manuscript and made numerous helpful suggestions. Remaining errors and conclusions are the author's responsibility.

I INTRODUCTION

The enactment by Congress of the 1954 Watershed Protection and Flood Prevention Act (PL 566) made available to states and local communities matching funds for use in the development of water and other natural resources of small watersheds.[1] In Minnesota, as in most other states, Pl 566 has had a large impact on the structure of both state and local institutions having primary responsibility for water resource management and on the type and magnitude of their expenditures. This study examines small watershed planning in Minnesota within the framework established by PL 566.

1.1 PL 566 and small watershed planning in Minnesota

In response to PL 566, the state legislature acted in 1955 to improve surface water management in Minnesota's small watersheds and to facilitate cooperation of local communities in the PL 566 program. The Minnesota Watershed Act of 1955 repealed some earlier, largely ineffective surface water legislation and authorized the creation of watershed districts.[2] Watershed districts are special-purpose local governments with geographic limits defined by the physical boundaries of minor drainage basins. They are established by the State Water Resources Board upon petition by residents or local governments from each proposed district. The districts have sufficient powers to act as sponsors and administrators of PL 566 projects.

Since the inception of the PL 566 program, 59 individual projects have been proposed in Minnesota. Several of these were sponsored by watershed districts acting jointly with other local agencies. In general, watershed districts are not coextensive with, and are larger than, PL 566 watershed areas. The legislature's intent in providing the legal authority for watershed districts was to enable creation of local governmental units which would be able to sponsor PL 566 projects, but which would also serve to coordinate water resource investments over broader areas than could be encompassed by single projects.[3]

Coordination, review, and priority rankings of proposed watershed development projects under PL 566 are made at three levels: the watershed district level; statewide by the State Soil Conservation Committee; and nationally by the Office of the Administrator of the Soil Conservation Service.

A proposed PL 566 project is approved for construction only after all interested parties have accepted a project work plan detailing technical requirements and all probable costs and benefits. To gain final acceptance, a project work plan must propose a set of improvements which are technically and administratively feasible and for which benefits exceed costs for each separable segment. Also, the set of improvements must be such that they would not be implemented by private individuals or by government agencies acting under authorization of programs other than PL 566.

1.2 Problems and sources of inefficiency

Despite the extensive process of review and coordination of Minnesota's small watershed development projects, inefficient allocation of investment capital may occur both within and between PL 566 projects and watershed districts. Problems in allocation of capital by watershed management agencies result from the interaction of two types of factors: technical planning deficiencies; and market imperfections.

Among the technical planning problems frequently arising in watershed development are failures to include all primary costs and benefits in the economic evaluation of projects, the use of interest rates which do not accurately reflect the cost of investment capital, and failures to evaluate feasible alternative methods for achieving project objectives. Perhaps more important are errors in estimation of project costs and benefits and misspecification of project objectives.

Market imperfections that contribute to inefficient small

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[1] U.S. Congress, Watershed Protection and Flood Prevention Act, Public Law 566, 83rd Congress, 2nd Session, 1954. For the purposes of PL 566, small watersheds are defined as watershed or subwatershed areas that do not exceed 250,000 acres.

[2] Minnesota Statutes, Ch. 112, sec. 34-85.

[3] Minnesota Department of Conservation, Division of Waters, Hydrologic Atlas of Minnesota, Bulletin No. 10 (St. Paul, Minnesota, April 1959) pp. 21-22.

watershed investments often arise from government programs and policies. Examples are quotas and price supports for some agricultural commodities, politically determined interest rates, and provision of direct subsidies and low interest loans to private project participants.

Among the problems affecting development decisions are several important sources of inefficiency in the allocation and use of resources that are available for small watershed development in Minnesota.

Extensive land treatment measures by individual participants are required for PL 566 project structural improvements.[4] However, the net benefits or losses that could reasonably be expected from these required measures are not included in assessing economic feasibility. Failure to include these costs and any extra associated benefits biases the estimates of benefit-cost ratios. If additional benefits are, in fact, less than additional costs, the bias is toward justification of projects or project segments that may not be economically viable. A similar outcome arises out of the failure to evaluate the economic effects of project structures designed to create or enhance wildlife environment. Under PL 566, structures designed for wildlife purposes are considered to be economically justified if local cooperators agree to bear one-half the structural costs and to provide maintenance. Because wildlife benefits are difficult to identify and measure, it may not be practical to require strict economic justification of wildlife structures. However, some economic analysis is required to insure that other more valuable uses of available investment capital are not displaced.

Efficiency in the allocation of investment capital within and among small watersheds is also affected by the level of capital charges used in the planning process. Currently, an interest rate of 4½ percent is used in estimating annual project costs. This biases resource allocation toward capital-intensive projects and results in the approval of investments which would not be made at market interest rates or even at the subsidized rates actually paid by project participants.

Another characteristic of small watershed planning is spatial dissociation of costs from benefits. For example, land management practices or water control structures upstream have significant effects upon flooding in downstream areas; downstream channel improvements reduce flood damages in upstream areas. Because of benefit-cost dissociations of this kind, it is difficult to identify and estimate all benefits and costs of particular projects, project components, or project purposes.[5] Furthermore, benefits or costs which accrue outside of a project area are often not included in the project analysis. Failure to identify, estimate, and weigh all effects, including externalities, contributes to allocational inefficiency.

Finally, the efficiency of allocation of investment capital among Minnesota small watershed projects has been influenced by the general failure to formulate areawide plans in sufficient detail and accuracy to allow recognition of projects or individual improvements promising large benefits per unit of costs. Even cursory examination of the work plans for PL 566 watersheds exposes large differences (100 percent or more) in benefit-cost ratios between adjacent projects. The least promising project is often initiated first. This situation may be explainable by the requirement both by PL 566 and by the Minnesota Watershed Act that projects be initiated locally. However, this explanation does not diminish the importance of obtaining efficiency in resource use.

1.3 Hypothesis and objectives

1.3.1 Hypothesis

The general hypothesis providing the raison d' être for this study was: because of their legal, political, and operational characteristics, the institutions involved in making small watershed investments in Minnesota fail to apply adequate economic analysis to the problems of watershed management. They do not arrive at public expenditure decisions which are efficient when evaluated either at the level of small watershed, minor drainage basin, or national society.

1.3.2 Objectives

The objectives of the study were to evaluate the real economic effects of investment decisions made by public institutions responsible for flood control and water management in small watersheds of Minnesota and to suggest changes in institutional structures and procedures which would make possible or facilitate improved decisionmaking performance.

1.4 Method of analysis

1.4.1 Procedure

To achieve the study objectives, the following descriptive

[4] PL 566 requires that, prior to project approval, owners of at least 50 percent of the land in the drainage area above proposed structural improvements complete farm conservation plans and enter agreements to implement recommended land treatment practices. Land treatment must be scheduled for completion concurrently with structural improvements. Among the normally recommended land treatment practices are tillage and other cropping practices which must be applied annually and more permanent land use adjustments, tree plantings, and structural measures such as field drainage ditches and drainage mains.

[5] For this study, the term "project component" is defined as a distinct physical structural measure or set of measures planned for inclusion in a project. Each project is comprised of one or more separate components. "Project purpose" refers to separate project purposes, i.e. flood control, drainage, wildlife enhancement, or recreation.

and numerical analyses—corresponding to the five remaining chapters of this report—were made.

Chapter II A description of the legal framework, the institutions, and the operational procedures involved in making small watershed management decisions in Minnesota.

Chapter III A description and criticism of the assumptions and methods of analysis used in small watershed planning in Minnesota.

Chapter IV An evaluation, using economic efficiency criteria, of the small watershed projects approved under the authority of PL 566 in Minnesota.

Chapter V An evaluation for a small study area of the economic efficiency of intra-watershed and interwatershed investment decisions assuming various capital and size-of-planning unit restrictions.

Chapter VI Proposal of a feasible institutional framework and decision model which would yield improved decisions with respect to investments and management of small watersheds.

1.4.2 Economic efficiency criteria

The formal economic criteria used in evaluating investment decisions of watershed management agencies (Chapters IV and V) can be stated as simple benefit-cost ratios. A decision to implement a particular watershed development project from among a set of m possible projects (i = 1, ...m) is economically justified when the following conditions are met:

(1) The estimated total project benefit-cost ratio (R_i) is equal to or greater than 1, i.e.,

$$R_i = \frac{\sum_j \sum_k B_{ijk}}{\sum_j \sum_k C_{ijk}} \geq 1 \quad \text{where}$$

B_{ijk} = the average annual benefits for the kth purpose generated by the jth component of the ith project, explicitly

B_{i11} = drainage benefits of drainage and flood control structures

B_{i12} = flood control benefits of drainage and flood control structures

B_{i23} = fish and wildlife benefits of wildlife and/or recreation structures

B_{i24} = recreation benefits of wildlife and/or recreation structures

B_{i35} = independent land treatment benefits of land treatment measures

C_{ijk} = the average annual cost of the kth purpose of the jth component of the ith project ($C_{ij} = \overline{C}_{ij} f_n + \overline{\overline{C}}_{ij}$, where $\overline{C}_{ij}$ = the total installation cost of the jth project component; f_n = the amortization factor, the annual payment which would have to be made to retire a debt of \$1 at the end of a specified number of years, n, assuming a constant interest rate, r; $\overline{\overline{C}}_{ij}$ = the average annual operation and maintenance cost of the jth project component)

C_{i1} = costs of drainage and flood control structures

C_{i2} = costs of wildlife and/or recreation structures

C_{i3} = costs of land treatment measures

(2) The benefit-cost ratio (r_{ij}') for each independent[6] component (j') of the project is equal to or greater than 1

$$r'_{ij} = \frac{\sum_k B'_{ijk}}{C'_{ij}} \geq 1, \text{ for each } j'$$

[6] A project component (j) is independent (j') if it can be completed independently and if none of the benefits attributed to it are conditional upon the completion of any other project component.

(3) The benefit-cost ratio (r_{ik}') for each independent purpose[7] of the project is equal to or greater than 1

$$r'_{ik} = \frac{\sum_j B'_{ijk}}{\sum_j C'_{ijk}} \geq 1, \text{ where}$$

B_{ijk} = the average annual benefits of the kth purpose generated by the component j of project i, and C_{ijk} = the average annual cost of the kth purpose of the jth component

(4) The total project benefit cost ratio R_i is greater than the ratio for similar projects of comparable size that would be delayed or excluded from implementation by a decision to implement project i.

Each of the four criteria specified above must be met for a proposed watershed development project to be judged an economically efficient use of public investment funds. Furthermore, several other assumptions with respect to planning parameters and procedures must also be fulfilled:

1. All product prices used in the estimation of project benefits must reflect, as accurately as possible, prices which can be expected to prevail during the time period in which benefits are generated.
2. Similarly, resource prices and project costs must reflect actual expected prices and costs. All costs must be included.
3. The net value of external effects of project measures must be 0.
4. All feasible alternative means to achieve project objectives must be evaluated.

[7] A project purpose (k) is any separable part of one or more project components and is independent (k) if it meets the criteria applied in evaluating the independence of components (see footnote 6).

II DECISION FRAMEWORK FOR WATERSHED MANAGEMENT IN MINNESOTA[8]

2.1 The legal framework

Three statutes, one federal and two state, form the basic legal framework within which almost all small watershed planning and development is done in Minnesota. PL 566, the Watershed Protection and Flood Prevention Act, defines the federal interest in small watershed development and establishes the nature of development which is eligible for federal assistance.[9] The legal authorization in Minnesota derives primarily from the Minnesota Watershed Act[10] and the Minnesota Drainage Code.[11] The following descriptions are based upon these three laws including amendments, through 1969, to the original legislation.

2.1.1 PL 566

PL 566 was enacted in 1954 to enable the federal government to encourage and aid the development of small watersheds—those too small for traditional flood control or reclamation projects, yet too large to be developed and managed effectively by local groups working together.

To insure that watershed development schemes proposed under PL 566 are of the nature envisioned by Congress, specific limitations were established with respect to the size of the covered watersheds and individual flood control structures. Total area of a PL 566 watershed is limited to 250,000 acres; the maximum allowable capacity of any single control structure is 25,000 acre-feet, only one-half of which can be floodwater detention capacity. Furthermore, any proposed plan for which the federal share is more than $250,000 or which has any structure providing more than 2,500 acre-feet of total capacity must be approved by the U.S. Congress through committee resolution in both the House and Senate. However, the act largely negates total watershed size and expenditure limitations by providing that watersheds which are component parts of a larger watershed may be planned together. Also, the Department of Agriculture, which administers the PL 566 program, is authorized to cooperate with other agencies in planning and developing larger basins.

For proposed PL 566 watersheds which meet the specified limitations, the federal government is authorized to furnish technical and financial assistance. Subject to the limitations stated above, the Secretary of Agriculture is the agent of the federal government with authority to accept or reject applications for PL 566 assistance. To be considered by the secretary, applications must be approved by the state agency having PL 566 supervisory authority in each state. In Minnesota, this is the State Soil Conservation Committee. Federal assistance authorized by PL 566 includes:

1. All project planning costs—including engineering costs
2. All construction costs of flood control structures and up to 50 percent of construction costs of structural measures for drainage, recreation, and wildlife development
3. Up to 50 percent of the costs of acquiring land for wildlife or recreation development
4. Costs of land treatment measures up to the rates of assistance for similar practices under other federal programs[12]
5. Loans, at federal long term interest rates, to local sponsors to finance the local share of costs

To qualify for federal assistance under the act, local sponsors are required to:

1. Acquire necessary easements, rights-of-way, and water rights
2. Bear all project costs not specifically authorized for federal payment, including all operation and maintenance costs
3. Obtain agreements to carry out Soil Conservation Service farm plans on at least 50 percent of the agricultural land within watershed boundaries and above project structures
4. Submit a satisfactory plan for repayment of any loans made under the act

Federal funding of PL 566 is through annual Congressional appropriations. The Secretary of Agriculture is authorized to distribute this among projects eligible for planning or implementation funds, i.e. those which have met the stated requirements of the act. Appropri-

[8] For an earlier, more complete description of the framework for small watershed planning in Minnesota, see Virgil C. Herrick and Philip M. Raup, Organizational Problems in Developing the Small Watersheds of Minnesota, Station Bulletin 437 (Minnesota Agricultural Experiment Station, St. Paul, January 1957). Also see U.S. Department of Agriculture, Soil Conservation Service, Multiple-Purpose Watershed Projects Under Public Law 566, PA 575 (Washington, U.S. Government Printing Office, January 1970).

[9] U.S. Code Annotated, Title 16, Chapter 18, section 1001-1009.

[10] Minnesota Statutes 1967, Chapter 112, section 34-85. Laws of Minnesota 1969, pp. 1917-1919, 2186-2194.

[11] Minnesota Statutes 1967, Chapter 106, section 011-673.

[12] Most federal assistance for land treatment practices is in the form of matching grants to farmers under the Agricultural Conservation Program. For some practices assistance ranges up to eighty percent of total installation costs. However, the average rate for all practices is about 50 percent in Minnesota. (Unpublished data available in the files of the Agricultural Stabilization and Conservation Service, St. Paul).

ated funds need not be spent within 1 year; they remain available until expended.

2.1.2 Minnesota Watershed Act

Specifically designed to enable participation of Minnesota communities in the PL 566 program, the Minnesota Watershed Act provides for the creation of watershed districts empowered to act as local sponsors of PL 566 watersheds. Because of the PL 566 requirements that local sponsors obtain property rights and assume financial responsibility for the local share of project costs, few public agencies in Minnesota have sufficient powers to act in this capacity.[13] Watershed districts do have these powers.

Watershed districts are special agencies of the State of Minnesota with corporate powers similar to those of other autonomous local governments. They have perpetual succession, the right to participate in legal contracts and proceedings, and other powers normally held by corporate bodies. In addition, they can exercise eminent domain, levy both special assessment and general property taxes, issue revenue bonds, regulate resource use within their boundaries, and initiate watershed improvements for the general benefit of the district. Furthermore, they are specifically authorized to implement and maintain improvement projects (such as PL 566 watersheds) which are not of general benefit to all district residents. However, such projects can be implemented only upon petition and approval of affected parties, and local costs must be financed through assessment of beneficiaries.

To insure that separate projects within a watershed district do not conflict with one another, each district must prepare an overall plan for resource management to which all individual projects approved by the district managers must conform. The district plans must meet the approval of the Minnesota Water Resources Board and must be reviewed at least biennially by the board and the watershed managers.

The watershed act does not limit the physical size of watershed districts, but provides that a district "...may include the whole or any part of any watershed or watersheds within the discretion of the Water Resources Board..."[14] However, all established districts are confined to identifiable small drainage basins—ranging in size from about 40 square miles up to almost 6,000 square miles.[15] The inherent potential for coordination of planning on a watershedwide basis is shown by the absence of limitations on district size. This potential is further enhanced by the grant of authority for cooperation with other districts or public agencies in planning and implementation.

Although authorized funding for most district purposes appears to be adequate, districtwide planning funds probably are not. The organizational expense fund for each district is limited to the proceeds of an ad valorem tax levy not to exceed the lesser of 2 mills per dollar of assessed value of taxable property in the district or $60,000. This fund can be used for district organizational expenses and for preparation of the overall district plan. Additional funds are available for planning individual improvements but apparently not for districtwide planning.

2.1.3 Minnesota Drainage Code

The Minnesota Drainage Code provides authorization for the only alternative to watershed districts as legal sponsors of PL 566 watershed projects. Under the drainage code, both county boards of commissioners and district courts of each judicial district are authorized to establish legal drainage systems which may also include works for flood control or "other public purposes." Such drainage systems may be established only after petition by resident landowners owning at least 60 percent of the land in the proposed system, onsite inspection by viewers, and by a professional engineer, and after public hearings.

Drainage systems which lie entirely within one county may be established either by the county board or by the district court having jurisdiction in that county. Systems which extend into two or more counties can only be established by a district court—with jurisdiction to the district court in which the original petition for establishment is filed. However for both county ditches and judicial ditches, the county board(s) of the county (or counties) affected administers the system once it is established. The board(s) is (are) the legal sponsor(s) for participation in the PL 566 program and can perform all functions required of local sponsors.

Financing local costs of construction and maintenance of county or judicial drainage systems is through the issuance of revenue bonds with a maximum interest rate of 6 percent and a maximum life to maturity of 23 years. Bonds are retired by assessment of benefited lands.

2.1.4 Administrative regulations

As important as statutory limitations in their effects upon the planning and development of small watersheds is the relevant body of quasi-legal administrative regulations. Administrative regulations for planning and implementing PL 566 projects were established by an executive order of the Presi-

[13] Among local government agencies, only municipal or county governments, watershed districts, and the district courts have the powers of eminent domain and of taxation which are essential for performance of these functions. The effectiveness of municipal and county governments is obviously limited by their geographic boundaries which seldom correspond to complete watersheds.

[14] Minnesota Statues, Chapter 112, section 36.

[15] From unpublished data available at the offices of the Minnesota Water Resources Board, St. Paul.

dent in 1954.[16] The order authorizes the Secretary of Agriculture to establish such guidelines as he thinks necessary, including:

1. Criteria for formulation and justification of project plans and for cost sharing between the federal government and other project participants.

2. Engineering and economic standards and objectives, including the degrees of flood protection to be provided by project measures.

3. Specification of structural and land treatment measures eligible for federal assistance.

Under this authority, guidelines for planning and evaluating proposed PL 566 watersheds have been developed and formalized within the Soil Conservation Service, the agency assigned primary authority for the program by PL 566 and the Secretary of Agriculture. Those most important from the standpoint of total plan formulation and evaluation are summarized in the Economics Guide for Watershed Protection and Flood Prevention.[17]

General statements of principles underlying watershed planning under PL 566 include:

* Watershed planning and analysis should result in plans which are beneficial from the broad public (national) viewpoint.

* No project purpose or measure should be included for which tangible benefits, i.e. quantifiable benefits, do not at least equal costs; therefore, "careful economic analysis is needed to make sure that no purposes (or measures) are included that lack economic justification..."[18]

* "The cost to society of capital utilization is determined by the productive opportunities over time that are foregone."[19]

More specific planning constraints include:

* Land treatment measures are the basic element of any watershed project and must be installed before any other project measures can be justified. This statement is interpreted operationally to mean that land treatment measures required in PL 566 projects are not included in analyses of project feasibility.

* The associated costs of project measures, i.e. the increased on-farm costs necessary to allow achievement of full project benefits, are deducted from gross benefits to determine the amount of benefits used in economic analysis.

* The appropriate interest rate to use for discounting benefits, amortizing costs, and converting benefits and costs to a common time is the current long-term federal interest rate.

Not included in the Economics Guide but also an important planning guideline of the SCS is:

* If local sponsors will contribute at least 50 percent of the installation costs (including right-of-way, easement, and land costs) of fish and wildlife measures, these measures are considered, for the purposes of project justification, to be economically feasible.[20]

Obvious conflicts arise between the general principles (points 1-3) and the more specific constraints (points 4-7) stated above. The implications of each for watershed planning are discussed in Chapter III.

2.2 Planning agencies

Several public agencies are involved in planning small watershed projects in Minnesota. This section briefly outlines the role of each of these agencies in small watershed planning.

2.2.1 Soil and water conservation districts

Soil and water conservation districts have been established in 84 of Minnesota's 87 counties.[21] The districts, governed by elected boards, are special units of government with corporate status, perpetual succession, and substantial autonomy from other governmental units.

Soil and water conservation districts primarily coordinate Soil Conservation Service assistance for soil and water management on individual farms. They also promote resource conservation and development throughout their district areas and are active in the initiation and planning of PL 566 watershed projects. But in Minnesota, because they lack the power of eminent domain and have no revenue sources other than grants from other agencies, they cannot perform all the functions required of local sponsors of PL 566 projects. Therefore, these districts often seek establishment of watershed districts or county or judicial drainage systems to act as legal sponsors of PL 566 applications which they have initiated.

2.2.2 Watershed districts

Watershed districts are the local government units in Minnesota which have primary responsibility for coordinating the develop-

[16] U.S. Code Annotated, Title 16, Chapter 18, section 1006.

[17] U.S. Department of Agriculture, Soil Conservation Service, Economics Guide for Watershed Protection and Flood Prevention, (Washington: USDA/SCS, March 1964) Chapter 1-2.

[18] Ibid., p. 2.

[19] Ibid., p. 17.

[20] See: USDA/SCS, Work Plan Tamarac River Watershed Marshall Kittson and Roseau Counties in Minnesota (unpublished mimeo. report, 1965) p. 55; USDA/SCS, Work Plan Joe River Watershed-Kittson County, Minnesota (unpublished mimeo. report, 1963) p. 15.

[21] Soil and water conservation districts are authorized in Minnesota by the Minnesota Soil Conservation Districts Law (Minnesota Statutes, Chapter 40, section 01-15). A more complete description of the structure, functions, and legal authority of these districts and other planning agencies is given in Thomas E. Daves, "National Resource Special Districts in Minnesota" (unpublished manuscript, University of Minnesota, 1968).

ment and management of natural resources on a watershedwide basis. These districts (twenty-four are active in Minnesota) are governed by elected boards and are independent units of local government. They have all the powers, including those of taxation and eminent domain, necessary to discharge their watershed management responsibilities.

Although watershed districts are specifically designed to act as local sponsors of PL 566 projects, in numerous cases they have been established only after planning for a PL 566 project has been initiated by a soil conservation district and the need for a legally qualified local sponsor is seen. Consequently, these districts are often unable to perform their planning and coordination functions effectively. They are still being established while major planning efforts are being completed by other interested agencies, primarily SCS.

2.2.3 County boards and district courts

Minnesota law designates elected county boards of commissioners as the governing boards of the several counties.[22] These boards have broad administrative powers for county affairs, including explicit authority to perform any functions prescribed by legislative act, such as the functions specified in the drainage code (see subsection 2.1.2).[23]

Minnesota is divided into 10 judicial districts designated by statute.[24] Each district is served by a district court with two or more elected judges presiding.

The district courts' jurisdiction and responsibility in watershed management are specified in the drainage code (see subsection 2.1.3). Basically, they can accept petitions, perform or cause to be performed necessary investigations and hearings, and establish judicial ditches. They then delegate administration of the established judicial ditch (system) to the county boards of the counties in which the system lies. But they retain authority to hear and dispose of petitions pertaining to any business of the system that county boards cannot routinely settle. Petitions of this nature might include requests to withdraw or to increase the size of the system, adjust benefit assessments, etc.

2.2.4 Minnesota Water Resources Board

The Minnesota Water Resources Board is an agency of the state government.[25]

The board has general responsibility for promoting the public interest in water resource use and management. It serves primarily in an advisory capacity, providing a forum for analyzing specific water-related problems as they are affected by the whole body of Minnesota water law. If a substantial question of water policy arises, legal proceedings brought before the board—either through petition or on referral by another agency or the courts—are determined by the board after public hearings. This determination is given in the form of recommendations to the interested agencies.

The board also has authority to create watershed districts, to periodically approve and review district plans, and to decide appeals by individuals or agencies affected by district actions.

2.2.5 State Soil Conservation Committee

The State Soil Conservation Committee is also a state agency with primarily advisory responsibilities.[26] The committee has nine members, five of whom must be active farmers. The remaining four ex officio members are state officials. Also meeting with the committee as an advisory member is the state conservationist of the U.S. Soil Conservation Service.

Duties and powers of the committee include general supervision and assistance to soil and water conservation districts and the screening of applications for federal assistance under PL 566. In the latter case, the committee is the legal agent of the State of Minnesota for approval and priority ranking of PL 566 applications.

2.2.6 U.S. Soil Conservation Service

The Soil Conservation Service (SCS) has three important roles in Minnesota small watershed development. First, as the agency responsible for administration of PL 566, SCS has developed the guidelines used for planning all watershed projects involving SCS technical aid and/or federal financial contributions. Furthermore, the SCS has authority to allocate funds for project planning and implementation among qualified projects—provided those projects do not require a federal contribution of over $250,000 and meet certain structural size limitations (see subsection 2.1.1).[27]

Second, the professional watershed planning staff in the state offices of the SCS—including engineers, hydrologists, economists, and geologists—perform almost all the detailed planning included in PL 566 watershed work plans and support materials.

And finally, much of the initial field survey work, preliminary planning, and aid in preparing applications for PL 566 assistance is done by SCS watershed work units. These work units typically include mumbers trained in engineering, hydrology, soil science, and agronomy.

Because almost all small watershed planning and development now done in Minnesota is with PL

22 Minnesota Statutes, Chapter 375, section 01.

23 Minnesota Statutes, Chapter 375, section 18, subdivision 13.

24 Ibid., Chapter 2, section 722.

25 Minnesota Statutes, Chapter 105, sections 71-81.

26 Ibid., Chapter 40, section 03.

27 The authority to approve beginning of construction on projects within the specified cost and size limitations has been delegated to the SCS State Conservationist in each state (USDA/SCS, Multiple Purpose Watershed Projects, p. 7).

2.3 The planning process

566 assistance, the basic procedures are those prescribed by PL 566.[28] To initiate a PL 566 project, an application for federal planning assistance is prepared by local project sponsors.[29] The application expresses the local sponsors' perception of watershed problems and feasible improvements to solve them. It also specifies the probable level of federal assistance needed and the contribution of local participants.

The application for PL 566 assistance is then sent to the State Soil Conservation Committee which may approve or disapprove. If the application is approved, it is assigned a priority rating which ranks it among other unserviced planning assistance applications in the state. As planning assistance funds become available to the state (from SCS), these priority ratings are criteria for fund allocation. Considerations entering the priority ratings include the degree of support for the project throughout the project area, the ability of local sponsors to meet all legal and financial obligations, the levels of soil conservation practices now being applied in the project area, and the number of prospective beneficiaries. In addition, projects in Minnesota are rated on a numerical scale that assigns values to nine items including several of those listed above and also current damage levels, percentage of the watershed in cropland, land values, possibility of damage reduction through use of structures, and the contribution which the project would make to wildlife and recreation values and to downstream flood control.[30]

[28] The sources used in this description include unpublished materials available at the SCS state offices in St. Paul, and USDA/SCS, Multiple Purpose Watershed Projects.

[29] At this stage in the planning process, a local sponsor with full capability to perform all local financial functions is not required. Therefore in Minnesota, most projects have been initiated with soil conservation districts as the primary local sponsors. In general, watershed districts or legal ditch systems have been organized in project areas only after PL 566 planning is well underway—often after the PL 566 project work plan has been approved by SCS for implementation.

[30] For a discussion of the rating system used in Minnesota see Herrick and Raup, *op. cit.*, pp. 19-21.

If a particular project is given a high priority rating by the State Soil Conservation Committee, the SCS makes an extensive preliminary investigation of the physical and economic feasibility of developing a plan which would meet project objectives. The preliminary investigation involves all professional capabilities of the state SCS planning staff and calls upon experts from other interested agencies such as the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the Minnesota Conservation Department. The investigation results in a project proposal detailing preliminary estimates of costs and benefits and technical requirements. The proposal is reviewed by all interested agencies, including local sponsors. If this preliminary proposal is approved by the sponsors and the SCS state conservationist, authorization by the SCS administrator to prepare a project work plan is requested.

Development of the final project work plan is again primarily the work of the state SCS planning staff. Specialized assistance is obtained from other agencies and from SCS work unit personnel in the project area. For this final plan, extensive field surveys are made to obtain reliable estimates of all physical and economic requirements and effects of proposed (and alternative) project measures. If it appears that the project will be feasible both physically and economically, a draft work plan is constructed. The draft plan is reviewed by agencies acting as local sponsors during the planning process, by the SCS watershed planning unit in Washington, and, if necessary, by the appropriate congressional committees. Public hearings are held locally. If approved by all participating agencies, the completed work plan becomes the basis for project implementation.

However for project implementation to proceed, a legally qualified and responsible local sponsor is required by PL 566. And in Minnesota, it is most often at this stage that the State Water Resources Board is petitioned to create a watershed district to act as the legal sponsor. Obviously in these cases, the watershed district board, as such, has no role in project planning.

III A CRITIQUE OF WATERSHED PLANNING PROCEDURES

Small watersheds under PL 566 are largely financed with federal funds. Therefore, the applicable viewpoint for project evaluation is that of society as a whole. The primary criterion for project evaluation is whether the resources expended are allocated so that the resources will yield as high a return in social benefits as they would in alternative uses. The general objective is maximization of social welfare. Operationally, this requires that the sum of all project benefits, wherever they accrue, be equal to or greater than all project costs wherever they fall.

However, tangible watershed improvement objectives are specified by local participants. Professional planning personnel seek to develop watershed plans which, if implemented, would solve problems that local participants want solved. With this objective, technical planning of PL 566 projects is a process of designing a system of structural and/or nonstructural measures which (1) will solve the expressed watershed problems to an acceptable degree, (2) is least costly from among a reasonable and effective set of alternatives, and (3) has a present value of expected total benefits at least equal to the present value of expected total costs.

In this chapter, procedures used in planning PL 566 projects are evaluated to determine whether they facilitate attainment of the general and specific project objectives outlined above. Methods used by the Soil Conservation Service (SCS) in estimating project costs, benefits, and benefit-cost ratios are described briefly and are subjected to theoretical criticism.

3.1 Project costs

3.1.1 Procedures for cost estimation

The costs of implementing structural and land treatment measures designed for PL 566 projects are classified as installation, operation and maintenance, and induced costs. Cost estimation procedures used by SCS are outlined fully in the Economics Guide.[31]

Installation costs. Project installation costs include costs of construction, technical and legal services, and land, easements, and rights-of-way. Planning costs are almost all borne by SCS and are not included in the costs of individual projects.

Construction costs are estimated by applying standard cost coefficients to the physical operations required. For example, the construction costs of enlarging a channel is the volume of excavation required multiplied by the average (or normal) base-year cost per unit volume under the relevant physical conditions (soil, topography, etc.). Unit construction costs are assumed constant over the construction period.

Estimates of the costs of technical services—primarily engineering services provided by SCS—are based upon the cost of providing the services, including salaries, materials, and overhead. The estimated costs of legal or other services required for contract administration are the market rates for the particular services required.

Land, easements, and rights-of-way are acquired either through negotiation between individual property owners and the local sponsors or through condemnation. Estimates of fair market value of these property rights are obtained using one or more of three property appraisal procedures: comparison with sales of similar lands or rights in the market; capitalization of net income streams; and determination of replacement cost.

[31] The discussion is based upon information obtained in conversations with Soil Conservation Service personnel, from the individual watershed work plans, and from SCS Economics Guide.

Total real costs of property acquisition are included in project cost estimates, whether property is donated or purchased.

Operation and maintenance costs. The basic assumption underlying estimation of operation and maintenance costs is that works of improvement must be operated and maintained so that they will deliver throughout the life of the project the full benefits for which they were designed. For most PL 566 projects, these costs involve largely maintenance, including annual and periodic repairs and replacement of any project components expected to have a lifetime shorter than the project. Typically, operation costs include the costs of regulating water levels or flows using manually operated gates and administration and servicing of recreational and wildlife areas. Although these costs fluctuate from year to year, annual average operation and maintenance costs are estimated by applying projected long term prices (unit costs) to average levels of services and materials required.

Induced costs. The Economics Guide defines induced costs as "... all uncompensated adverse effects in goods and services caused by the construction or operations of a project."[32] Examples of such costs include production losses in excess of estimated damages to lands used (or restricted in use) by the project, detrimental downstream effects, and damages to fish and wildlife resources.

There is no indication in any of the project work plans studied that any induced costs were included in project analyses. Induced costs of the first two types are understandably absent. If estimation of the costs of obtaining land, easements, and rights-of-way is adequately done, there would be no induced costs of the first type, i.e. all production losses of this nature are accounted for in the property acquisition costs. Similarly, detrimental downstream effects can be accounted for in the estimated cash or opportunity costs of flowage easements.

[32] Ibid., p. 38.

The third type of induced costs, however, is likely to occur. Drainage of swamplands and increased intensity of land use are common results of small watershed projects. Wildlife habitat almost inevitably suffers.

Associated costs. In addition to the project costs described earlier, associated costs—classified as nonproject or extra-project costs by the Soil Conservation Service—are included in project analyses. Associated costs are costs over and above project costs necessary to attain the benefits attributed to structural measures. The two types of associated costs usually considered are costs of changing land use patterns (land clearing and construction of field drainage) and increased onfarm production costs necessary to achieve increased output.

Estimating the costs of changing land use is done in the same way as estimating construction costs. If changing land use requires land clearing, cost per acre multiplied by the number of acres to be cleared is the associated cost estimate. Increased production costs are estimated using farm budgeting techniques. Costs of production inputs necessary without the project are subtracted from input costs for with-project conditions.

Total costs. Not all costs estimated for a small watershed project are included when total costs (used in deriving project or project component benefit-cost ratios) are assembled. Land treatment measures by land owners are excluded by administrative decision of SCS.[33] And, although associated costs are included in project benefit-cost analyses, they are not included with other costs on the cost side of the ratio. Rather, they are treated as "negative benefits" and are subtracted from gross project benefits.

[33] Ibid., Ch. 2, p. 1.

Before annual total project costs can be determined, installation costs of structural measures must be converted to an annual basis. This is done by amortizing capital expenditures over the planned project lifetime—50 years for all Minnesota projects. The rate of interest assumed for amortization purposes is the base-year nominal long term federal interest rate established by the Treasury Department. For the 13 study projects, the assumed rate ranged from 2 1/2 percent to 3 1/8 percent.

With the SCS exclusion of land treatment and associated costs, annual project costs become the sum of the annualized value of installation costs, annual operation and maintenance costs, and annual induced costs.

3.1.2 Criticism of cost estimation procedures

Cost estimation procedures for PL 566 projects can be criticized on several counts.

Changing construction costs. Unless a single structure takes more than 2 years to complete or unless the total planned project construction period is substantially more than 5 years, unit construction costs are assumed constant over the construction period. Also, delays between the planning base year and approval for construction are ignored if they are not too long.[34]

The effects this assumption of constant unit costs can have on the accuracy of cost estimation can be illustrated with the use of the composite construction cost index of the U.S. Department of Commerce. From 1946 to 1966, this index rose from 56 to 121, an average annual increase of 3.9 percent (compounded) in construction costs.[35] For the average project, expenditures made in the 1st year of construction would be nearly 8 percent higher than planned. In the 5th year of construction, expenditures would be 27 percent higher than planned. Depending upon the time distribution of capital outlays, failure to take account of the time lag can have a serious effect on project planning, distorting estimates of absolute dollar cost levels for individual projects and also benefit-cost ratios between projects.

Induced costs. There is apparently no attempt by watershed planners to measure the losses of fish and wildlife resources attributable to project measures. Nor are the real costs (values) of such losses given equal attention with similar benefits in estimating the intangible effects of project development. Measurement of these costs is difficult, but some attempt to incorporate them in project evaluation is desirable if maximizing public welfare is the prime criterion for justification. Recent research on the evaluation of the social costs of loss of wildlife habitat might prove useful in devising methods for cost estimation.[36] For project evaluation, the benefits of fish and wildlife habitat could be considered to be equal to the costs of their creation and the costs of destroying habitat estimated by using replacement cost techniques. This could be done by determining the quantities of particular classes of habitat destroyed and multiplying these by replacement costs. These replacement costs are well-documented in watershed work plans where development of wildlife habitat is an objective.

Associated costs. There is general agreement among both economic theorists and watershed planning economists that the current method of treating associated costs in watershed project planning is acceptable. As explained in subsection 3.1.1. above, the current method is to subtract associated costs (both the costs of additional production inputs and the onfarm or other extraproject costs of changing or intensifying land use) from gross project benefits to obtain an estimate of net benefits to project measures.

The theoretical argument for this method is that locally borne costs should be subtracted from gross project benefits because federal capital is taken to be the limiting factor in watershed development. All other inputs are assumed to be freely available at market prices. Therefore by maximizing the rate of return on federal capital, the production of the greatest possible stream of future values will be assured.[37]

However, this treatment of associated costs tends to cause misallocation of resources unless benefits equal to associated costs would be generated by implementation of the onfarm or other extra-project measures, whether or not the project is completed; or complementarity between project and extra-project measures is such that benefits obtainable by implementing extra-project measures alone plus the share of project benefits attributable to extra-project measures is equal to their cost. If neither of these two conditions holds, this

[34] For the 13 projects studied, the time from the planning base year to the end of the construction period averaged between 6 and 7 years: One to 2 years delay before approval, and a 5-year planned construction period. One project was not approved until 5 years after the base year, resulting in a lapse of 10 years between the base year and planned completion of construction. Another project planned but not yet approved, the South of Hawley-South of Buffalo project, has a proposed construction period of 8 years with no consideration given to changing unit costs of construction.

[35] U.S. Department of Commerce, Census Bureau, Statistical Abstract of the United States (88th ed.; Washington: U.S. Government Printing Office, 1967), p. 716. The composite construction cost index relates the cost, in current dollars for each year, of a bundle of construction outputs to the cost of a similar bundle in a base period (1957-1959) valued at base period prices. Hence, changes in the index numbers over time reflect both changes in technology and in unit prices of particular production inputs.

[36] See Jon Heller Goldstein, "An Economic Analysis of the Wetlands Problem in Minnesota" (unpublished Ph. D. dissertation, Department of Economics, University of Minnesota, 1967).

[37] For an elaboration of this argument, see Otto Eckstein, Water Resources Development: The Economics of Project Evaluation (Cambridge, Mass.; Harvard University Press, 1965), pp. 61-65.

method leads either to overestimation or underestimation of the benefits generated by project measures.

Obviously, the magnitude of error caused by this procedure depends upon the ratio of associated costs to gross benefits and the average size of error per unit cost of extra-project measures. Because the error per unit costs is probably not calculable given current techniques, the gross error for any given project is indeterminate. However, if associated costs are large with respect to gross benefits, the error can be assumed to be significant.

Furthermore, even if the benefits of extra-project measures just equal their costs, evaluation of project feasibility on the basis of only project costs and benefits would, under all but one unique set of circumstances, cause a misallocation of resources. Efficient resource allocation would require also that the ratios of extra-project to project costs (and benefits) be equal for all alternative projects. For example, assume two projects competing for limited public investment funds are equivalent in technical and political feasibility and also require approximately the same total (public and private) investment to install project measures. With the maximization of net benefits per unit of cost as a primary investment allocation criterion (with a budget constraint), the project having the higher net benefit-cost ratio would get priority in funding. If, however, this project also required substantially higher extra-project expenditures, the total (project plus extra-project) benefit-cost ratio might well be higher for the alternative project. Thus, failure to estimate a total benefit-cost ratio could result in giving priority in resource allocation to a project yielding a lower rate of return than a known feasible alternative.

The argument that federal capital is the meaningful constraint on which the rate of return should be maximized would seem to imply that the above conclusion is trivial. But a large proportion of nonPL 566 capital—about 50 percent of all land treatment costs—is provided by the cost sharing provisions of the Agricultural Conservation Program (ACP).[38] The remaining funds other than PL 566 and ACP come in Minnesota from state conservation funds (for the local share of wildlife improvements) and from local beneficiaries. The local share is financed in total by loans from the Farmers Home Administration at substantially lower than market interest rates.[39] In short, all the initial outlay for watershed development under PL 566 comes from government funds, primarily federal. There would seem to be no logical reason for excluding any costs or benefits to obtain an estimate of the rate of return to federal capital. The potential for misallocation is real and could easily be eliminated by treating associated costs and benefits in the same manner as project costs and benefits.

Land treatment measures. Criticism similar to that leveled against the treatment of associated costs can be made about the failure to include the costs of land treatment measures in project benefit-cost analyses.

Land treatment measures are, according to the Economics Guide,

> ...the basic element of any watershed project and shall be considered the nucleus or initial increment for project formulation. All other measures shall be justified for inclusion in the project on the basis that the land treatment measures scheduled for completion in the watershed work plan have been completed.[40]

Furthermore, these measures are, in the standard phraseology of watershed work plans, "essential for the proper functioning of the works of improvement."

However, as stated earlier, the costs and "independent benefits" of land treatment measures are not included in project analyses. The justification used for their exclusion is given in the following statement:

> Extensive research and experience over many years has shown that land treatment measures which are acceptable to and will be installed by landowners almost universally produce benefits far in excess of costs.[41]

Even if—as this statement asserts—the benefits of land treatment measures which are acceptable to and will be installed by landowners do far exceed costs,[42] the exclusion of land treatment measures from economic analysis of PL 566 project is still not justified. There is no assurance that programmed measures would be installed by (or even acceptable to) landowners without the very substantial incentives of ACP cost sharing, of low-interest loans from the FHA, and of project benefits accruing to landowners but generated by structures largely paid for by PL 566 funds. Also,

38 U.S.D.A. Agricultural Stabilization and Conservation Service, Agricultural Conservation Program, Summary by States (1964), p. 1.

39 The interest rate for loans to finance the local share of PL 566 project investment has, since inception of the program, been about 3 percent (in July of 1969 the rate was increased to 3.4 percent). Loans made under this program must be repaid no later than 23 years after the loan date. (Unpublished data available in the files of the Farmers Home Administration, St. Paul).

40 Economics Guide, Ch. 2, p. 1.

41 Carl B. Brown, "Economics and Financing of Irrigation, Drainage, and Flood Control Works," (mimeographed paper presented at the Second Technical Conference on Irrigation, Drainage, and Flood Control, Omaha, Nebraska, May 16, 1962), p. 5. Underlining added.

42 At least one researcher seems to argue that this statement is not universally true. See Herbert Warren Grubb, "Individual and Aggregate Benefits and Costs of Soil Conservation in the South," (unpublished Ph. D. dissertation, Department of Agricultural Economics, North Carolina State University, 1964).

how much land treatment benefits exceed costs no doubt varies widely among projects. As was argued for associated costs, efficient resource allocation requires that such variation be taken into account in project evaluations. And finally, some land treatment measures are of such a nature that their generation of benefits in excess of those attributed to project measures is extremely doubtful. Particularly questionable are open field ditches and drainage laterals or mains which undoubtedly are essential if project drainage benefits are to accrue.

The potential for distortion in resource allocation resulting from failure to include land treatment measures in project evaluations may be indicated by this fact: for the 13 approved projects in Minnesota, 43 percent of total project installation costs tabulated in project workplans are the costs of installing land treatment measures (see table 4.2) Not included in computing this percentage are the extra-project (associated cost) measures which would also be classified as land treatment.

The interest rate. Federal administrative policy requires that investment costs of water resource projects involving federal expenditures be amortized at the current rate of long term federal bonds. This rate is considered appropriate because:

1. It is the government's cost of obtaining funds.
2. It is a measure of time-related value differences of essentially risk-free investments.
3. It is an approximation of the social time preference rate which takes into account the preferences of future as well as present generations; market interest rates are attuned only to the preferences of the present generation.

Each of these points will be considered in turn.

1. The long term federal interest rate may be the cost to government of obtaining investment capital, but the relevant cost to be considered in evaluating projects from society's point of view is society's cost of using funds for this purpose. What is the opportunity cost in terms of foregone current consumption and/or future consumption which might be generated by alternative public or private investments? It can be argued that the cost to society is the weighted average cost of all federal funds collected, including both borrowed and tax revenues.[43] An interest rate based on this cost would be higher than the bond rate because, although federal borrowing primarily taps funds which would otherwise be held idle or used in other low return investments, taxes extract funds both from current consumption and high return investments.

2. Federal water resource investments are riskless to lenders who are assured repayment by the fiscal and monetary power of the federal government. But the risk is not zero that benefits over time will not be sufficient to cover all costs. Obviously, this borrowers' risk is as high for federal water resources projects as it is for similar private projects such as large power complexes or cooperative drainage or irrigation projects. The risk of not returning expected benefits may be particularly high for small watershed projects designed primarily to improve agricultural land. Increased production in other areas and/or changing governmental policies with respect to quotas, land retirement programs, and price supports may have large negative effects on project benefits.

3. A social rate of time preference which gives more weight to future consumption than individual rates of time preference assumes that the saving consumption actions of individuals (and private firms) reflect too little concern for the welfare of future generations. This assumption is a value judgment which may be valid.[44] However, if there is a need for redistribution of income (consumption) toward the future, economic efficiency requires maximization of future income streams per unit of current consumption given up. And the future income stream generated by a particular rate of investment (forgone current consumption) is maximized by channeling capital into the most profitable public or private alternative—assuming, of course, that capital committed to investment is reinvested perpetually. As borrowers' risk is not necessarily higher for private investments, optimal patterns would be achieved by setting both private and public interest rates at the same level.

This also leads to arguments, readily available in the literature, that water resource investments have unique or intangible benefits which justify lower rates. Water resource investments (and conservation in general) are said to be merit investments because, in addition to those benefits accruing from increased agricultural output, they preserve irreplaceable natural resources. This argument is questionable; the same government investing in such projects is also allocating large sums to drain marshlands, inundate magnificent canyons, and subsidize the exploitation of limited mineral wealth. Secondly, the often expressed need to expand the nation's food and fiber resource base for national security reasons or to insure adequate future productive capacity is also questionable. For every acre of cropland gained or improved through small watershed projects, several others are retired or underutilized because of price relationships and government

43 Krutilla and Eckstein argue that the cost of tax revenue alone is the real social cost of federal financing. John W. Krutilla and Otto Eckstein, Multiple Purpose River Development-Studies in Applied Economic Analysis (Baltimore, Maryland: Johns Hopkins Press, 1958), pp. 78-130.

44 The standard arguments are that people are shortsighted about their own or their successors' future needs and/or that in the marketplace they will not reveal their preference for public goods, of which consumption by future generations is a form. See A.R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey," The Economic Journal, LXXV (December, 1965), p. 697.

programs. With almost certain continued advancements in technology, the need for more land resources is not likely to arise within the projected physical lifetimes of any projects now being implemented.

If the long term federal bond rate is not an appropriate rate to use in evaluating public investments in water resources, what is an appropriate rate? Among alternatives which have been proposed are rates ranging from around 4.5 percent up to 10 or 15 percent.[45] Most contributors, however, suggest a rate somewhere between the federal bond rate and an estimated risk-adjusted rate of return on private investment, i.e. for the early 1960's between 3 and 10 percent. In the following analysis of actual watershed planning in Chapter IV, interest rates of 4 and 6 percent were used. Four percent illustrates the effects which even minor increases in the interest rate can have on project benefit-cost ratios. Six percent is a compromise rate, high enough to illustrate the distorting resource allocation effects of an artificially low interest rate, yet not pressing at the bounds of credibility on the high side.

The obvious effect of evaluating project planning using a discount rate higher than those used in the original project analyses is to increase estimates of annual project costs. The increase in costs will be greater on those projects which are relatively capital-intensive and/or which have shorter economic lifetimes.

3.2 Project benefits

This section describes briefly and criticizes benefit estimation procedures used in PL 566 project planning.

3.2.1 Procedures for benefit estimation

The procedures outlined below are those currently used to estimate benefits of PL 566 watershed projects and are described fully in the Economics Guide.[46]

Flood prevention benefits. The benefits of flood prevention or, more accurately, floodwater control are usually attributed to three different sources: damage reduction; more intensive land use; and changed land use.

For most PL 566 projects, damage reduction benefits are largely reduction in damages to crops and/or cropland. Benefits are computed as increased net incomes farmers would receive by being able to increase production because of project improvements. Estimates of production increases are based upon the farmer's expectations of what production would be without the project and with the project (floodfree). The farmer's expectations are obtained through personal interviews and are compared with yield and output information available from other sources. Resulting estimates are also verified or adjusted by professional assessment of yield possibilities based upon detailed studies of soil types and climatic conditions. Finally, net increases in production between existing and floodfree conditions are adjusted to account for the frequency and magnitudes of floods which would occur even with project development. To convert estimated production increases to net income (benefit) terms, increased production and associated production expenses are valued at projected long term prices.[47] Farm budgets with project and without project are then constructed, and expected net increases in farm incomes are estimated.

Other damage reductions include loss of livestock, fences, farm equipment, etc. Average losses which would occur without the project were estimated and compared with losses to be expected with the project. The physical amounts of loss reduction were valued at long term prices to estimate project benefits.

Benefits of reducing flood damages to structures and nonagricultural lands are computed on the basis of historical damage data. For example, because project measures are usually designed to eliminate damage to bridges and highways, damage reduction benefits equal to average annual bridge and highway maintenance costs resulting from past flooding in the watershed are attributed to project measures. Urban damage reduction benefits are estimated similarly. Data on past damages are obtained primarily from county and municipal governments. All cost estimates are adjusted to reflect projected long term prices.

Reductions of indirect damages from flooding—disruptions of travel, communications, or other services—are considered project benefits. These indirect benefits are usually estimated as a percent of direct benefits, ranging from 5 to 25 percent. Indirect benefits of reducing flood damages to agricultural land are assumed to be between 5 and 10 percent of direct benefits. For highways, bridges, and railroads, indirect damage reduction benefits are assumed to be from 15 to 25 percent of direct benefits.

[45] For justifications of the low and high rates, respectively, see William L. Miller, "The Magnitude of the Discount Rate for Government Projects," Southern Economic Journal, XLVIII (April, 1962), pp. 348-356, and Ian M.D. Little and James A. Mirrlees, Manual of Industrial Project Analysis in Developing Countries, Vol II, Social Cost-Benefit Analysis (Paris: Development Center of the Organization for Economic Cooperation and Development, 1967), pp. 181-189.

[46] Op. Cit., Ch. 3-12.

[47] The projected prices used are presented in: U.S.D.A., Agricultural Research Service and Agricultural Marketing Service, "Agricultural Price and Cost Projections," 1957 (mimeographed). The projected prices are the average 1953-1955 prices for the various commodities adjusted to reflect 1910-14 relative prices. The rather heroic set of assumptions underlying these projections include expectations of: (a) relatively high employment; (b) a trend toward peace; (c) continued population and economic growth; (d) a stable general price level; and (3) "production and demand requirements in balance under competitive conditions" (p. 4).

Benefits of changed land use made possible by flood control arise from increasing the amount of land in higher use categories, i.e. from conversion of idle land to managed woodlot or pasture, woodlot or pasture to cropland, cropland to residential, residential to industrial, etc. More intensive land use benefits are those generated by more intensive use of land which remains within a particular use category. Examples of this type of benefit include introduction of higher value crops on cropland previously susceptible to flooding, use of more purchased inputs on crops, development and management of park or wildlife lands, and upgrading industrial use such as from scrapyard to factory site.

Benefits from different or more intensive use of agricultural land are estimated in the same manner as benefits to reduced flood damage. This involves determining increased (or decreased) production of the various crops or livestock products and valuing the changes at projected long term prices. From this estimate of the gross increase in value of output are subtracted increased production costs and associated land clearing or other costs necessary to achieve expected production increases. Nonagricultural benefits are normally estimated at the increased sale or rental value of (nonagricultural) improved lands as determined by appraisal. Estimation procedures for benefits to improvement of wildlife and recreational lands are discussed below.

In assessing benefits from increased production, some account is taken of the existence of surpluses of some agricultural commodities. The Economics Guide urges caution and conservatism in the estimation of benefits to be generated by crops now in surplus (under supply control).[48] Recently, administrative policy of the Soil Conservation Service was changed so that no benefits can be counted for changing land use to cropland to be used for surplus crops.[49] However, benefits attributed to more intensive land use or to reduced flood damages are not restricted in this manner.

Drainage benefits. The benefits of drainage measures for agricultural lands (called agricultural water management benefits by the SCS) are estimated using the increased net income method described above for estimating benefits to flood control. Net increases in farmers' incomes resulting from drainage measures are determined by using farm budget analyses with and without the project to estimate production and production input levels on drained lands. Production and production inputs with and without the project are valued at projected long term prices. Additional purchased inputs necessary to obtain full project benefits are included as costs. Other extra-project (associated) costs necessary for the projected increases are not included in the budget analyses, but they are subtracted from the net increases in income. The result is an estimate of net benefits to project measures. Extra-project measures normally excluded from the project evaluation are field and auxiliary ditches necessary for drainage, and the land clearing, fencing, etc., which may be required for land use changes.

For flood control measures, no project benefits can be counted for bringing into production by drainage new land that is to be used for producing surplus crops. However, increased production of surplus crops on existing cropland given improved drainage can be counted.

Fish and wildlife benefits. In practice, benefits generated from measures designed to develop or improve fish or wildlife habitat are not estimated in PL 566 project analyses. However if included as a project objective, these measures are assumed to generate annual benefits equal to their annual total costs. The Economics Guide suggests that if fish and wildlife benefits were to be estimated they might "...be measured in terms of the cost of the cheapest alternative source of obtaining equivalent benefits that would most likely be utilized in the absence of the project."[50]

Recreation benefits. Estimation of the benefits generated by project measures designed for recreation or of benefits provided incidentally involves projecting the rate of use in visitor days per year and multiplying that number by a fixed value (benefit) of 1 visitor day of recreation. A visitor day is defined as a visit during 1 day by one person to a recreation site, regardless of how long he stays. In estimating visitor days, consideration is given to use of similar facilities in other similar areas, projected population and income growth in the area, access, competing facilities, etc. The fixed benefits generated per visitor day of recreation are outlined in the Economics Guide and range from 50 cents to $1.50, depending upon the extent and quality of the facilities provided.[51]

At the present time, watershed improvement measures designed for recreation are included in the project analysis only if recreation is a stated project purpose. If recreation is merely auxiliary to other purposes of project measures, any additional investments required to provide recreation are considered justified if local interests are willing to bear operation and maintenance and one-half of total installation costs.

Water supply benefits. In evaluating small watershed projects, the SCS does not directly estimate benefits to municipal or industrial water supply measures included as a project purpose. It merely requires that there be a need for the facility, that the least costly means for obtaining water be used, and the water not be so expensive that population or industrial migration

48 Op. Cit., Ch. 4, p. 4.

49 Irwin C. Ford (Agricultural Economist, SCS, Washington) quoted in the Proceedings of the SCS Midwest Regional Economists' Workshop, Lincoln, Nebraska, June 3-5, 1969. p. 3, unpublished.

50 Op. cit., Ch. 9, p. 7.

51 Ibid., p. 4.

would be a lower cost alternative. When water supply is incidental to other project purposes, water supply benefits are estimated to be the quantity of water required (projected use rate) multiplied by the difference between separable costs of water supply from the project source and the costs of water supply from the least costly alternative.

Secondary benefits. Secondary benefits[52] are excluded by SCS regulations from estimates of small watershed project benefit-cost ratios. However to enhance prospects of project approval, most watershed work plans include statements that extensive secondary benefits will also be generated by project measures. Furthermore, secondary benefits are often quantified for presentation in the work plans and were included in the benefit-cost ratios estimated for five of the 13 study projects. The standard amount of secondary benefits attributed to a project is the sum of 10 percent of primary benefits, 10 percent of project operation and maintenance costs, and 10 percent of associated costs. Benefits which these percentages are used to approximate are those "stemming" from and "induced" by project measures. Stemming benefits are increased local outputs of transportation, processing, marketing, or other services required to handle increased production generated by the project (the project primary benefits). Induced benefits are the increased sales of physical inputs and services required to enable the generation of project benefits (project operation and maintenance costs and associated costs).

Total benefits. Estimated total annual benefits used for project benefit-cost ratios are the sum of estimated values for each of the benefits described earlier excluding fish and wildlife, recreation and water supply improvements not specified as project purposes, and secondary benefits. In estimating each type of benefit, expected lag in benefit accrual is accounted for by discounting. Although the Economics Guide specifies a discount rate equal to current long term federal interest rates,[53] the SCS used a rate of 4 percent in discounting benefits for most of the study projects.

3.2.2 Criticism of benefit estimation procedures

Some of the criticisms of cost estimation procedures (subsection 3.1.2) apply as well to benefit estimation procedures. Arbitrary exclusion of some measures from the analysis and the use of unrealistic interest rates are examples. Also, because of the identity relationship between costs and benefits (costs are negative benefits), the arguments with respect to cost estimation procedures have application in the estimation of benefits.

Adjustments for time lag. In the planning of PL 566 projects, adjustments are made for time lag in accrual of project benefits. However, the interest rate used in discounting delayed benefits is lower than what might be considered a reasonable social time preference rate.[54] Haveman suggests that the rate used in discounting benefits should be 1 or 2 percent above the social cost of capital (probably higher than the social time preference rate). This allows for the higher degree of uncertainty that prospective future benefits will indeed be forthcoming.[55] The probability that estimated benefits will not be obtained is higher than for costs because benefits are subject to more time delay than are costs. Full benefits to project measures usually do not accrue until a project has been fully installed and in operation for some time, while most project costs are incurred during the construction period.

Benefits occur late in the economic lifetime of projects, and this also has implications for the effects of changing the discount rate. Increasing the discount rate causes substantially more reduction in the estimated present value of benefits (or costs) generated in the far future than of benefits (or costs) generated in the near future.[56] Obviously, the level of interest rate used for discounting project benefits is of critical importance. Other things being equal, high rates favor projects with benefits accruing early in the project lifetime, and low rates favor those with a longer or later payoff period.

The low interest rates used in discounting benefits for the study projects (4 percent maximum), therefore, are subject to criticism. This is because they probably underestimate the social time preference rate (and the marginal productivity of private investment) and because they favor projects with benefits coming late in the project lifetime—benefits which are more subject to error in estimation.

Net benefit estimation. Extra-project associated costs are subtracted from gross increases in revenue generated by a project to yield an estimate of benefits attributable to project measures. Arguments against this procedure for cost (and net benefit) estimation were presented in subsection 3.1.2 of this chapter. However, one point should be stressed. Extra-project measures such as land clear-

52 "Secondary benefits are defined as the values added over and above the immediate products or services of the project as a result of activities 'stemming from' or 'induced by' the project." Ibid., Ch. 11, p. 1.

53 Op. cit., Ch. 1, p. 7.

54 See the discussion of interest rates in sub section 3.1.2.

55 Robert H. Haveman, Water Resource Investment and the Public Interest (Nashville, Tennessee: Vanderbilt University Press, 1965), pp. 156-177.

56 For example, suppose there is a project with $1,000 of benefits generated in the 10th year and another $1,000 in the 50th year. Discounted at 4 percent the present values of these benefits are $656 and $141, respectively. Assuming a 6 percent discount rate, the present values become $588 for the 10th year benefits and $54 for the 50th year benefits. Increasing the discount rate 50 percent resulted in a much smaller decrease in present value of benefits generated in the 10th year (15 percent decrease) than those generated in the 50th year (62 percent decrease).

ing, permanent ditch construction, tiling, etc., are fixed investments which must be made if project benefits are to be realized. Gross benefits generated by project and extra-project measures are estimated under the assumption that all measures are installed. There are no estimates made of benefits to projects constructed without necessary extra-project measures. Yet, such benefits may well be very low if extra-project measures are essential. Therefore, subtraction of associated costs from gross benefits may lead to substantial overestimation of benefits to project measures.

Land treatment benefits. Land treatment measures that PL 566 regulations require as prerequisites to installation of project structural measures are assumed by watershed planners to generate benefits in addition to those attributed to the structural measures. These additional benefits are assumed to be sufficient to justify the installation and maintenance of land treatment measures. Therefore, the costs and additional (or independent) benefits of these measures are not included in project benefit-cost analyses.

However for the study watersheds, more than 50 percent of the total installation costs of land treatment measures are for field and auxiliary drainage ditches. These ditches would generate few benefits without adequate outlets provided by project structural improvements. Nor would any significant proportion of drainage benefits attributed to project structural measures be forthcoming without these ditches. Furthermore, agricultural benefits of a watershed project are estimated by determining increases in net farm incomes caused by project installation, including land treatment measures. This procedure attributes all benefits to project structural measures, implying that there are no independent land treatment benefits.

The obvious conclusion is that independent land treatment benefits (if they exist) should be estimated and explicitly included, together with land treatment costs, in PL 566 project analyses.

Fish and wildlife and recreation benefits. In planning PL 566 watersheds, it is assumed that watershed improvements designed to provide or enhance fish and wildlife habitat or recreation facilities are justified if local participants agree to bear one-half of installation costs and all operation and maintenance costs. This assumption implies that benefits from such improvements are at least equal to costs. However, it actually requires only that they be slightly greater than one-half of total costs–i.e. equal to the portion of total costs borne by local participants.[57] Even if benefits are equal to (or greater than) total costs, without specific estimates of benefits there is no way to determine whether a particular improvement represents an efficient use of limited capital.

Total benefits. If the stated goals of using resources efficiently and maximizing benefits to society are to be achieved, total benefits (and costs) of all watershed improvements planned should be estimated and included directly in project analysis. Benefits not now included which should be added are: (1) benefits of necessary extra-project measures; (2) benefits of required land treatment measures; and (3) benefits from measures or facilities designed for fish and wildlife or recreation purposes.

In discussing estimates of total benefits, it is also necessary to note that inclusion in watershed work plans of estimates or unquantified claims of secondary benefits is not only contrary to SCS project evaluation standards but is also questionable economics. Among the fundamental assumptions outlined in the Economics Guide are a national viewpoint for project analyses and full employment of resources.[58] Taken together, these assumptions rule out the possibility of secondary benefits–secondary benefits generated locally would be negated by losses in other areas. Furthermore, even if these assumptions are relaxed, local secondary benefits would be zero if all project inputs are priced at their opportunity costs and project outputs are sold in a competitive market. Total net benefits to project measures are reflected in primary benefit and cost estimates.

3.3 Project feasibility

Once the costs and benefits of implementing a small watershed project have been estimated, the economic feasibility of the project is evaluated. Average annual net benefits expected to be generated by the project are compared with estimated average annual costs. If net benefits are at least equal to costs, the project is pronounced economically feasible and becomes eligible for federal funding.

3.3.1 The economic feasibility criterion

The particular method of comparing benefits to costs used for PL 566 projects, i.e. comparing average annual net benefits and costs over the expected project lifetime, is analogous to a comparison of present values of net benefit and cost streams. In simplified form, the criterion used by SCS for evaluating project economic feasibility is

$$\frac{Bg - P - K_e - O_e}{K_p + O_p} \geq 1,$$

[57] This requires the further assumption, perhaps also questionable, that officials of local governments which are party to PL 566 project agreements are inclined and able to judge the benefits to their constituents of the proposed improvements.

If economically rational, local interests would participate in any project with direct local benefits greater than locally borne costs, assuming that interest rates used in computing local costs reflect true opportunity costs of this use of local capital. That is, local interests would participate in a project if the present value to them of benefits generated by total project expenditures (PL 566 plus local) is higher than the present value of benefits which they could obtain by allocating their (local) capital to the best alternative use.

[58] Op. cit., Ch. 1.

where

B_g = average annual gross project benefits

P = average annual increased variable production input costs

K_e = average annual capital costs of extraproject measures

O_e = average annual operation and maintenance costs of extra-project measures

K_p = average annual capital costs of project flood control and drainage structures

O_p = average annual operation and maintenance costs of project flood control and drainage structures.

3.3.2 Criticism of the criterion

Obvious shortcomings of this criterion have been discussed in the previous sections of this chapter dealing with cost and benefit estimation procedures. One of the primary criticisms is the inclusion of some costs on the benefit side of the ratio. This procedure has been justified by SCS on the ground that, because federal capital is the limiting factor in watershed development, optimal resource allocation requires priority for the project yielding the highest rate of return (benefits) to federal capital. Hence to facilitate judgments among projects, it is argued that the appropriate benefit-cost ratio is one which relates net benefits to federal capital expenditures.

However, the current practice in project analysis neither achieves this end nor should it. The benefit-cost ratio used places some private noncapital expenditures on the cost side—the operation and maintenance costs of project structures. And some federal capital expenditures are placed on the benefit side—usually about 50 percent of the capital costs of extra-project measures are borne by the federal Agricultural Conservation Program. The ratio used fails to indicate either the net benefits attributable to federal capital expenditures or even the net benefits to federal capital disbursed through the PL 566 program. To reflect net benefits to federal capital expenditures accurately, the benefit-cost ratio would take the form

$$\frac{B_g - P - K_{e1} - O_e - O_p}{K_p + K_{e2}} \geq 1$$

where

K_{e1} = the part of extra-project capital expenditures borne by private participants

K_{e2} = the part of extra-project capital expenditures borne by the federal government

This ratio also fails to measure the economic efficiency of a watershed project accurately because the distinction between federal and nonfederal capital is artificial when evaluating a project from society's viewpoint. Although federal budget limitations do exist, if expected project benefits are of sufficient magnitude to justify capital outlays in excess of the limited federal budget, the needed capital funds should be obtained through borrowing in the private capital market. Private capital funds are available in effectively unlimited amounts at market prices; therefore, capital funds for project development are limited only by the private market price of long term capital. Assuming that the market price truly represents the opportunity cost of not allocating capital to the next best alternative, capital expenditures for a particular project should be made and/or expanded as long as marginal net benefits generated exceed the marginal cost—the market rate of interest.[59]

Furthermore, inclusion of noncapital costs as negative benefits in the construction of an investment efficiency criterion obscures the true relationship between total benefits and total costs to society. A private entrepreneur is economically rational when he seeks to maximize net returns to his owned resources, regardless of the quantities of variable resources utilized. But investment decisions in the public sector are not necessarily rational when made on this basis. Public investment decisions must take into account the total cost to society—in terms of all scarce resources used—of obtaining a unit of return (social benefits). Any resource, whether investment capital or purchased inputs, allocated to a given project is thereby not available for alternative employment. A criterion which in effect disregards the amount of noncapital inputs required by particular projects fails to identify those projects promising greatest total benefits to society from a given stock (or flow) of resources.

If we wish to adjust to take account of the arguments made above (for public projects, distinction between federal and nonfederal capital is not valid, and total benefits must be compared with total costs to ascertain relative economic efficiency of projects) the investment criterion becomes:

$$\frac{B_g}{K + O + P} \geq 1$$

where

$$K = K_p + K_e$$

$$O = O_p + O_e$$

This ratio gives a measure of the total benefits to society of using a unit of its resources for a particular project or project segment. This criterion is essentially the same as condition (1) in subsection 1.4.2. of Chapter I.

[59] The private market interest rate is not necessarily a good measure of the social opportunity cost of capital, but it does represent a minimum social rate of return which should be expected from government-sponsored projects. Obviously, private investments must earn a rate of return above the market price of capital in order to allow payment of taxes on property and on income created by the investment.

IV EVALUATION OF WATERSHED PLANNING IN MINNESOTA

Of the 59 watershed protection and flood prevention (PL 566) watersheds that have been proposed in Minnesota, 13 have been approved for construction (table 4.1). The approved watersheds range in size from approximately 16,000 to

Table 4.1 Dates of implementation and size of the approved PL 566 watersheds and associated watershed districts in Minnesota, 1969

Watershed	Planning base year	Year approved for construction	Size (000 acres)	Cropland (000 acres)	Associated watershed district	Year established	Size (000 acres)
Rush-Pine Creek	1955	1956	88.0	52.4	Rushford area[1]	1952	14.1
*Coon Creek	1958	1963	55.3	21.7	Coon Creek	1959	54.4
Middle Fork of Two Rivers	1958	1960	57.5	31.6	Two Rivers	1957	693.7
*Bear Valley	1959	1961	29.4	24.6	Bear Valley	1961	29.4
North Branch of Two Rivers	1961	1962	234.3	91.2	Two Rivers	1957	693.7
Zippel	1961	1962	51.9	14.5	None	---	---
*Crooked Creek	1962	1963	44.6	22.3	Crooked Creek	1959	46.0
Crane Creek	1962	1963	66.7	50.0	None	--	--
Joe River	1962	1963	54.9	47.8	Joe River	1958	79.3
Cooks Valley	1963	1964	15.9	7.3	Cooks Valley	1963	28.1
*Lakes Okabena and Ocheda	1963	1965	46.4	35.5	Okabena-Ocheda	1960	48.0
Tamarac River	1963	1965	234.6	114.9	None	--	--
Janesville Village	1965	1967	69.4	46.7	None	--	--
Total			1,048.7	560.5			993.0
Average			80.7	43.1			110.3

* These PL 566 watersheds are essentially coincident with the associated watershed districts.

[1] The Rushford area district is a drainage and conservancy district. But it is quite similar to watershed districts in structure and authority.

Source: Unpublished data from the Soil Conservation Service, U.S. Department of Agriculture, and the Minnesota Water Resources Board.

235,000 acres and average 81,000 acres. Nine of the 13 watersheds are within watershed or drainage and conservancy districts. All except one (Coon Creek Watershed) are in rural areas with most of the project benefits attributed to flood control and drainage on agricultural land. Five of the watersheds include one or more structures designed exclusively for fish and wildlife protection or for recreation.

Estimated expenditures for installation of land treatment and structural measures proposed for the 13 watersheds total 10.7 million dollars. This is an average installation cost of $826,000 per watershed, $10 per watershed acre, and $19 per acre of cropland within the watersheds (tables 4.2 and

Table 4.2 Estimated installation costs for land treatment and structural measures, approved PL 566 watershed projects in Minnesota

Watershed	Estimated installation costs[1]								
	Land treatment measures			Structural measures			Total		
	PL 566 funds	Other[2]	Total	PL 566 funds	Other[2]	Total	PL 566 funds	Other[2]	Total
					(000 dollars)				
Rush-Pine Creek	33.6	261.1	294.7	15.9	15.6	31.5	49.5	276.7	326.2
Coon Creek	39.0	583.3	622.3	186.7	295.9	482.6	225.7	879.2	1,104.9
Middle Fork of Two Rivers	18.0	133.9	151.9	59.0	52.7	111.7	77.0	186.6	263.5
Bear Valley	30.4	180.7	211.2	146.5	6.7	153.2	176.9	187.5	364.4
North Branch of Two Rivers	70.0	297.2	367.2	123.3	64.6	188.0	193.3	361.8	555.2
Zippel	28.4	198.0	226.3	202.5	111.0	313.4	230.8	308.9	539.8
Crooked Creek	36.1	157.6	193.7	626.1	47.2	673.3	662.2	204.8	867.0
Crane Creek	65.9	592.2	658.1	548.6	285.0	833.6	614.4	877.2	1,491.7
Joe River	47.0	456.1	503.1	353.4	275.4	628.8	400.4	731.5	1,131.9
Cooks Valley	21.8	89.0	110.8	283.7	56.8	340.5	305.5	145.9	451.3
Lakes Okabena and Ocheda	25.6	111.1	136.7	182.2	198.2	380.4	207.8	309.4	517.1
Tamarac River	86.1	448.6	534.7	1,091.4	470.6	1,561.9	1,177.5	919.1	2,096.6
Janesville Village	38.9	621.7	660.5	222.6	149.8	372.4	261.4	771.5	1,033.0
Total	540.8	4,130.5	4,671.3	4,041.7	2,029.7	6,071.4	4,582.5	6,160.1	10,742.6
Average	41.6	317.7	359.3	310.9	156.1	467.0	352.5	473.8	826.4

1 The price bases used in estimating installation costs correspond to the planning base years of the respective projects (see table 4.1).

2 Other includes costs borne by state and local agencies, by private participants, and by the federal government under nonPL 566 programs.

Sources: Unpublished PL 566 watershed work plans available at the St. Paul office of the U.S. Soil Conservation Service.

Table 4.3 Estimated project installation costs per acre and per acre of cropland for approved PL 566 watersheds in Minnesota

Sources: Tables 4.1 and 4.2.

Watershed	Estimated installation costs: Per watershed acre: PL 566 funds	Other	Total	Per acre of cropland: PL 566 funds	Other	Total
	(dollars)					
Rush-Pine Creek	0.56	3.14	3.70	0.94	5.28	6.22
Coon Creek[1]	3.76	14.62	18.38	10.40	40.52	50.92
Middle Fork of Two Rivers	1.34	3.24	4.58	2.44	5.90	8.34
Bear Valley	6.02	6.38	12.40	7.19	7.62	14.81
North Branch of Two Rivers	0.82	1.54	2.36	2.12	3.97	6.09
Zippel	4.45	5.95	10.40	15.92	21.31	37.23
Crooked Creek	14.84	4.59	19.43	29.68	9.18	38.86
Crane Creek	9.21	13.15	22.36	12.29	17.54	29.83
Joe River	7.29	13.32	20.61	8.38	15.30	23.68
Cooks Valley	19.21	9.17	28.38	41.84	19.98	61.82
Lakes Okabena and Ocheda	4.48	6.67	11.15	5.85	8.71	14.56
Tamarac River	5.02	3.92	8.94	10.24	8.00	18.24
Janesville Village	3.77	11.12	14.89	5.60	16.52	22.12
Average	4.35	5.84	10.20	8.18	10.99	19.17

[1] Installation cost per acre of cropland is high for the Coon Creek Watershed because it is a largely urban district.

[2] Average installation costs were determined by dividing total expenditures in the 13 watersheds by total acreages.

4.3). The share of total installation expenditures to be paid by federal appropriations under PL 566 is $4,600,000 with the balance to be paid by state and by local project participants and by other federal programs.

Flood control was the major objective of the PL 566 projects proposed for each of the approved watersheds. Secondary objectives included provision of adequate drainage outlets for watershed lands and development of wildlife habitat and recreational facilities. The relative importance of these project objectives in the overall watershed improvement plans may be indicated by the levels of capital expenditures proposed to meet each type of objective.

Approximate cost distributions for structural improvements planned for the 13 watersheds were:

Flood control	$4.5 million
Drainage	0.8 million
Fish and wildlife	0.4 million
Recreation	0.3 million

Land treatment measures with an initial installation cost of $4,600,000 were also planned for the projects; most of this total was directed toward meeting erosion control and drainage objectives.

To evaluate the economic efficiency of watershed investment decisions made in Minnesota, the 13 watershed projects approved since enactment of PL 566 are examined in this chapter. Estimates of costs, benefits, and benefit-cost ratios presented in the project work plans are analyzed to determine the effects of incorporating changes in assumptions and procedures suggested by the theoretical arguments in Chapter III.

4.1 Cost adjustments

4.1.1 Changing construction costs

Each of the watershed projects studied was planned for completion over a 5-year period. Therefore, to evaluate the magnitude of possible distortion in cost estimates caused by construction costs changes over time, the planned costs of construction for each project were adjusted using the Department of Commerce index of construction costs for the relevant years.

Adjustments for unit construction cost changes over the planned construction period were made by multiplying the expenditures planned for each year (shown in the work plan) by the ratio of the cost index for that year to the index for the planning base year. In the project work plans, all installation costs were valued at planning base year unit costs. Therefore, this adjustment procedure yielded estimates of dollar construction costs with the costs incurred during each construction year reflecting the technology and construction input prices for that year rather than for the planning year. Adjusted installation costs computed were then discounted at a rate of 4 percent to obtain cost estimates as of project year 1. Table 4.4 shows the resulting net changes in estimated installation costs. These project year 1 cost estimates would be compared with benefit estimates discounted back to project year 1.

Referring to table 4.4, the original SCS estimates of total project installation costs for the 13 study watersheds were all higher than discounted estimates which accounted for unit cost changes during the 5-year construction period. For each project, costs adjusted for this lag and discounted

Table 4.4 **Installation costs for approved PL 566 watershed projects in Minnesota, nominal and project year 1 cost bases**

Watershed	Total installation costs: Nominal[1] dollars	Total installation costs: Project year 1[2] dollars	Adjusted less unadjusted: Dollars	Adjusted less unadjusted: Percent
Rush-Pine Creek	326,204	323,481	–2,723	–0.8
Coon Creek	1,104,922	1,074,530	–30,392	–2.8
Middle Fork of Two Rivers	263,538	255,872	–7,666	–2.9
Bear Valley	364,398	353,411	–10,987	–3.0
North Branch of Two Rivers	555,179	542,965	–12,214	–2.2
Zippel	539,781	530,710	–9,071	–1.7
Crooked Creek	861,984	840,620	–21,364	–2.5
Crane Creek	1,491,702	1,456,973	–34,729	–2.3
Joe River	1,131,924	1,105,616	–26,308	–2.3
Cooks Valley	451,344	447,246	–4,098	–0.9
Lakes Okabena and Ocheda	517,114	509,953	–7,161	–1.4
Tamarac River	2,096,616	2,061,044	–35,572	–1.7
Janesville Village	1,032,967	1,032,821	–146	0.0
Total	10,737,673	10,535,242	–202,431	–1.9

[1] The distributions of installation costs over the construction periods are given in the project work plans available in the St. Paul offices of the U.S. Soil Conservation Service.

[2] Conversion from nominal costs to a project year 1 base involved: (a) expenditures planned for each year of the construction period were converted from a planning year cost base to a year of expenditure cost base using the Department of Commerce Construction Cost Index (See table C.1 in Daves, "Small Watershed Management"); (b) the adjusted expenditures for each year were discounted at 4 percent and summed to obtain the initial year value.

to project year 1 were lower than unadjusted costs by an average of 2 percent. This means that estimates of benefit-cost ratios for these projects would rise as a result of this cost adjustment—assuming costs are discounted to year 1 values at a rate of 4 percent or higher. However because of different rates of annual expenditure, the percentage changes in installation costs range from 0 to 3 percent, indicating some changes in the relative size of benefit-cost ratios with the associated implications for resource allocation efficiency.

Adjustment for delay between project approval and initiation of structural measure construction was not attempted because of its origin in the political uncertainties of the federal budget. Usually at least 1 year delay in project funding has ranged up to 6 years for projects in Minnesota. Obviously, changes in installation costs arising from this type of delay are as important to accurate project evaluation as changes resulting from planned delays in construction. However, the funding delay may be zero for some projects, is quite variable, and is not predictable by project planners.

4.1.2 Project installation costs

For purposes of constructing benefit-cost ratios to be used in evaluating the economic efficiency of the 13 approved watershed projects, installation costs with the original planning year bases were used.

4.1.3 Associated costs

Because data with respect to associated costs arising from necessary extra-project measures were not readily available, estimates of these costs were obtained for only three of the projects included in the more detailed analysis of planning described in Chapter IV. Estimates were obtained for the Joe River, North Branch of Two Rivers, and Middle Fork of Two River watersheds. Annual associated costs estimated (by SCS) for these watersheds were:

Joe River	$23,080
North Branch of Two Rivers	2,758
Middle Fork of Two Rivers	6,305

These estimates represent the expected initial costs of changing land use patterns (amortized at 4 percent over the expected project lifetime) plus expected annual maintenance costs and additional production costs, valued at projected long term prices.

4.1.4 Annual costs

Comparison of benefits and costs of PL 566 projects is on an average annual benefit and cost basis. Therefore, installation costs must be annualized. To estimate annual installation costs under several sets of conditions, total installation costs for the study projects were amortized assuming project economic lifetimes of 50 years and three different interest rates: the rates actually used by

Table 4.5 **Estimated annual costs of land treatment and structural measures approved for PL 566 watershed projects in Minnesota, assuming project planning year cost bases**

Watershed	SCS interest rate, r[1] Percent	Annualized installation cost at r[1]	4%	6%	Annual operation and maintenance cost	Annualized total cost at r[1]	4%	6%
					(thousand dollars)			
Rush-Pine Creek	2 1/2	13.4	15.2	20.7	3.1	16.4	18.3	23.8
Coon Creek	2 1/2	39.0	51.4	70.1	9.8	48.8	61.2	79.9
Middle Fork of Two Rivers	2 1/2	9.3	12.3	16.7	2.9	12.2	15.2	19.6
Bear Valley	2 5/8	13.2	17.0	23.1	3.5	16.7	20.4	26.6
North Branch of Two Rivers	2 5/8	20.1	25.8	35.2	5.3	25.4	31.2	40.5
Zippel	2 7/8	20.5	25.1	34.2	5.6	26.1	30.8	39.9
Crooked Creek	2 7/8	28.1	36.7	52.9	4.7	32.8	41.4	57.6
Crane Creek	2 7/8	56.6	69.4	94.6	16.4	73.0	85.8	111.0
Joe River	2 7/8	43.0	52.7	71.8	11.8	54.8	64.5	83.6
Cooks Valley	3	17.3	20.8	28.5	2.8	20.1	23.6	31.3
Lakes Okabena and Ocheda	3 1/8	21.1	24.1	32.8	4.6	25.8	28.7	37.4
Tamarac River	3 1/8	83.4	97.6	133.0	19.0	102.5	116.6	152.0
Janesville Village	3 1/8	41.1	48.1	65.5	12.8	53.9	60.9	78.3
Total		406.1	496.2	679.1	102.3	508.5	598.6	781.5
Average		31.2	38.2	52.2	7.9	39.1	46.0	60.1

[1] The interest rates assumed by the Soil Conservation Service in amortizing installation costs of the particular project shown in column 1.

Source: These annual cost estimates were developed using installation and operation and maintenance cost data included in the unpublished project work plans which are available in the St. Paul offices of the U.S. Soil Conservation Service.

SCS (ranging between 2 1/2 and 3 1/8 percent); 4 percent; and 6 percent. Total annual costs for each project were then calculated by adding estimated annual operation and maintenance costs to the amortization cost estimates. Annual project costs estimated using the project planning year cost bases are summarized in table 4.5.

The effects on project costs of increasing interest rates are illustrated in table 4.5. Estimated total annual installation costs for the 13 projects increased by 22 percent when an interest rate of 4 percent was used rather than actual (SCS) rates. Use of a 6 percent rate resulted in an increase of 67 percent over the SCS estimates of annual installation costs and 37 percent over costs at 4 percent. Because annualized installation costs are more than two-thirds of total annual costs, changing interest rates for amortization also have a large effect on total annual costs. Total annual costs increased by 54 percent as a result of changing interest rates (from the levels used by SCS) to 6 percent.

Watershed work plan estimates of annual operation and maintenance costs of project structural measures were used in estimating total annual costs for these measures. However, no SCS estimates of operation and maintenance costs were available for land treatment measures. These costs were assumed to be equal to 1 percent of land treatment installation costs.[60]

4.2 Benefit adjustments

For the purpose of analyzing watershed planning, adjustments suggested by the criticisms of Chapter III were applied to benefit estimates made (by SCS) for the 13 study projects, This subsection describes the adjustments made and the resulting benefit estimates.

[60] This assumption was made because 1 percent of installation costs is roughly the annual costs of operation and maintenance estimated by SCS for project structural measures for the 13 study projects. A large proportion (over 50 percent) of planned land treatment expenditures for the study projects was for onfarm and auxiliary drainage ditches; therefore, it might reasonably be assumed that maintenance of land treatment measures, once established, would be of this order of magnitude. Also, the support data for the Joe River Watershed work plan indicate annual operation and maintenance costs of 1 percent and 5 percent of installation costs for auxiliary and onfarm drainage ditches, respectively. However, results obtained by Coutu, et. al., suggest that 1 percent is a gross underestimation for some practices. They estimated annual operation and maintenance costs for terraces, contour cultivation, and waterways to be about 32 percent of installation costs. For terracing without contour cultivation, the estimate was 18 percent. Arthur J. Coutu, W.W. McPherson, and Lee R. Martin, Methods for an Economic Evaluation of Soil Conservation Practices, Technical Bulletin 137, (North Carolina Agricultural Experiment Station, January 1959), p. 24.

Table 4.6 Estimated annual benefits of structural and land treatment measures approved for PL 566 watershed projects in Minnesota, assuming different levels of land treatment benefits

Watershed	Average annual benefits							
	Flood control and drainage	Wildlife and recreation[1]	Land treatment measures[2]			Total[2]		
			a	b	c	a	b	c
			(thousand dollars)					
Rush-Pine Creek	1.6		0	7.5	15.0	1.6	9.1	16.6
Coon Creek[3]	332.4		0	14.1	28.2	332.4	346.5	360.6
Middle Fork of Two Rivers	49.4		0	3.4	6.8	49.4	52.9	56.3
Bear Valley	7.5		0	4.9	9.7	7.5	12.4	17.3
North Branch of Two Rivers	8.9	(2.3)	0	8.5	16.9	11.2	19.6	28.1
Zippel	35.2		0	5.4	10.9	35.2	40.5	46.0
Crooked Creek	27.5	1.6	0	4.6	9.3	29.2	33.8	38.4
Crane Creek	46.3	(1.2)	0	15.8	31.6	47.6	63.4	79.2
Joe River	99.4	(.4)	0	12.1	24.1	99.8	111.8	123.9
Cooks Valley	15.0	1.0	0	2.7	5.4	16.0	18.7	21.4
Lakes Okabena and Ocheda	11.0	(36.6)[4]	0	3.7	7.4	47.5	51.2	54.9
Tamarac River	140.0	(14.7)[5]	0	13.3	26.6	154.8	168.1	181.4
Janesville Village	31.6	8.9	0	16.4	32.9	40.6	57.0	73.5
Total	805.8	66.7	0	112.4	224.9	872.6	985.0	1,097.4
Average	62.0	8.3	0	8.6	17.3	67.1	75.8	84.4

1 Numbers in parentheses are assumed benefit levels equal to average annual costs of wildlife or recreation measures.

2 Land treatment measures are assumed to generate independent benefits equal to: (a) zero; (b) one-half of the annual land treatment costs; and (c) annual land treatment costs (See table B.1 in Daves, "Small Watershed Management")

3 The high level of benefits estimated for Coon Creek reflects the fact that project improvements are largely for protection of a highly urbanized area (part of the Twin Cities metropolitan area).

4 This total includes $33,300 of recreation benefits and $752 water supply benefits estimated in the watershed work plan and $2,518 of assumed wildlife benefits.

5 This total includes $10,500 of recreation benefits and $4,247 of assumed wildlife benefits.

4.2.1 Total benefits

Together with the use of discount rates that are too low, potentially the most serious distortion in estimating benefits of small watershed projects is the failure to include benefits from all sources. To allow somewhat for this distortion, benefits to land treatment measures and wildlife and recreation improvements were assumed and added to estimated benefits from other sources.

Annual benefits to land treatment measures in addition to those already attributed to project structural measures were assumed at three different levels: (a) zero; (b) one-half of total annual land treatment costs at SCS interest rates; and (c) equal to total annual land treatment costs at SCS interest rates. These three assumptions represent conservative though quite optimistic expectations about independent benefits of land treatment measures. Assumption (b) is probably a fair compromise that illustrates yet does not overstate the effects on project analyses of including independent land treatment benefits (and costs). Estimates of project benefits under each of these assumptions are shown in table 4.6.

Also shown in table 4.6 are the estimated or assumed annual benefits of wildlife and recreation improvements proposed for the study watersheds. Benefit estimates for these improvements not made in the original project analyses are assumed to generate annual benefits equal to the sum (SCS interest rates) of their annual installation and operation and maintenance costs.[61]

4.2.2 Secondary benefits

Secondary benefits estimates which were included in the work plan benefit-cost ratios for five of the study projects were removed to allow the evaluation and comparison of projects in conformance with stated PL 566 planning policy.

61 Annual benefits at this level are somewhat low when compared to the direct estimates made by the Soil Conservation Service for similar improvements in some of the study watersheds. The weighted average benefit-cost ratio estimated for three recreation and two wildlife improvements was 2.2. However as is evident from the benefit-cost analyses in the next section of this chapter, wildlife and recreation improvements do not contribute enough to total benefits and costs for this underestimation to cause significant changes in total project ratios.

Table 4.7 Total flood control and drainage benefits estimated for three PL 566 watershed projects in Minnesota			
Watershed	Flood control and drainage benefits		
	Net income increases[1]	Associated costs	Total benefits
Joe River	$99,373	$23,080	$122,453
North Branch of Two Rivers	8,884	2,758	11,642
Middle Fork of Two Rivers	49,426	6,305	55,731

[1] Estimated gross increases in income on project-improved lands minus associated costs.

4.2.3 Net benefits

Estimates of associated costs—the capital costs of extra-project measures—were available for the Joe River, north branch of Two Rivers, and middle fork of Two Rivers watershed projects. To evaluate the effects of incorporating as direct benefits all benefits of extra-project measures, estimated flood control and drainage benefits were increased by the amount of associated costs. This adjustment is merely a reversal of the procedure actually followed of subtracting associated costs from gross income increases on project-improved lands to obtain net returns to project structural measures. The resulting numbers are estimates of total flood control and drainage benefits to both project and extra-project measures. (table 4.7).

4.3 Analysis of investment decisions

In the general analysis of 13 Minnesota watershed plans, the total benefit to total cost criterion suggested in subsection 3.3.2 of Chapter III was not used. Data with respect to additional production costs were not available. For most project plans, the work sheets of SCS economists showed only the changes in net agricultural returns expected to be generated by the project. Also, extra-project investment costs required for project success were not presented in project work plans and were found in the economic support data of only three of the four projects for which this information was sought. Therefore, the SCS criterion

$$\frac{B_g - P - K - O_e}{K_p + O_p} \geq 1$$

was used to evaluate the effects on project planning results of using different interest rates and benefit-cost combinations. However, an indication of the effects of having some costs on the benefit side of the ratio was developed for the three projects for which adequate data were available.

4.3.1 Effects of different interest rates

To assess the effects of interest rate changes on project feasibility and project ranking, benefit-cost ratios were computed assuming three different interest rates for estimating costs. Ratios were computed with installation costs amortized at the interest rates originally used by SCS (ranging between 2 1/2 amd 3 1/8 percent for the 13 projects); at 4 percent; and at 6 percent.[62] Benefit estimates used are those made by SCS in the watershed work plans (table 4.6).

Table 4.8 presents the benefit-cost ratios given in the project work plans and the results of interest rate changes. With benefit-cost ratios computed assuming the SCS's amortization interest rates as reference, the effects of increasing the interest rates to 4 percent and 6 percent are illustrated. At SCS rates, all of the project (drainage and flood control structure) benefit-cost ratios were greater than one, ranging from 1.09 to 16.14 (column 3) with the weighted average ratio for all projects at 3.26. With the interest rate increased to 4 percent, the aggregate ratio falls to 2.75. Five of the project benefit-cost ratios fall below 1. At 6 percent, 6 of the projects fail to achieve ratios of 1, and the aggregate ratio for all projects falls to 2.1.

The aggregate benefit-cost ratios presented have significance only in that they illustrate the magnitude of (weighted average) changes in project benefit-cost ratios associated with the specified changes in interest rates. Aggregate ratios do not measure the economic viability of any single project. As shown in table 4.8, although the aggregate benefit-cost ratio is 2.75 at 4 percent interest (1.77 when Coon Creek is excluded), five of the 13 projects have ratios less than 1.

In rank order based on benefit-cost ratio, five projects move up or down as a result of changing amortization rates from the SCS rates to 4 percent. Seven move up or down as rates increased from SCS rates to 6 percent; and six changed position when rates are increased from 4 to 6 percent. These shifts are due to differences in ratios of installation costs to total costs for the individual projects. The benefit-cost ratios for projects having relatively higher installation costs decline as amortization interest rates are increased.

The effects of increasing interest rates on aggregate benefits and costs for all projects are illustrated in table 4.9. Aggregate benefits,

[62] Amortization of installation costs involves dividing the initial capital outlays plus simple interest (on the declining balance) into equal annual installments payable over the project lifetime. The effects on annual project costs of making these rate changes are tabulated (table 4.5) and discussed in subsection 4.1.4 of this chapter.

Table 4.8 Study watershed projects: benefit-cost ratios of flood control and drainage structures, with installation costs amortized at three different interest rates

	SCS interest rate, r[1] (percent)	Benefit-cost ratios			
		WP[2]	r[3]	4 percent	6 percent
Rush-Pine Creek	2 1/2	1.09	1.09	0.97	0.73
Coon Creek	2 1/2	16.10	16.14	12.76	9.65
Middle Fork of Two Rivers	2 1/2	9.30	9.32	7.53	5.85
Bear Valley	2 5/8	1.09	1.09	0.88	0.68
North Branch of Two Rivers	2 5/8	1.44	1.44	1.19	0.92
Zippel	2 7/8	2.30	2.30	1.96	1.51
Crooked Creek	2 7/8	1.40*	1.21	0.93	0.66
Crane Creek	2 7/8	1.15	1.16	0.99	0.76
Joe River	2 7/8	3.30	3.28	2.79	2.16
Cooks Valley	3	1.30*	1.08	0.91	0.68
Lakes Okabena and Ocheda	3 1/8	3.10*	1.79	1.56	1.18
Tamarac River	3 1/8	2.40*	2.21	1.94	1.48
Janesville Village	3 1/8	2.30*	2.08	1.89	1.53
All watersheds (weighted average)		3.30	3.26	2.75	2.10
Rural watersheds[4]		2.17	2.09	1.77	1.36

1 The interest rates assumed by the Soil Conservation Service in amortizing project installation costs. Benefits for all projects were annualized assuming a 4 percent discount rate.

2 The project benefit-cost ratios estimated by the Soil Conservation Service and presented in the project work plans. Some of the estimates (*) include secondary benefits.

3 Benefit-cost ratios computed using the SCS interest rates but excluding secondary benefits from all total benefit estimates.

4 Coon Creek Watershed, which is largely urban, is excluded from this average.

Table 4.9 Study watershed projects: the effects on aggregated benefits and costs of using interest rates of 4 percent and 6 percent in amortizing installation costs[1]

	Rate of interest for amortization		
Item	r[2]	4 percent	6 percent
All projects (No.)	(13)	(13)	(13)
Total benefits	805,836	805,836	805,836
Total costs	247,474	292,940	384,500
B/C ratio	3.26	2.75	2.10
Projects with B/C's < 1 (No.)	(none)	(5)	(6)
Total benefits		97,959	106,843
Total costs		103,223	147,870
B/C ratio		0.95	0.72
Projects with B/C's ≥ 1 (No.)	(13)	(8)	(7)
Total benefits	805,836	707,877	698,993
Total costs	247,474	189,223	236,630
B/C ratio	3.26	3.74	2.95

1 Exclusion of the urban watershed (Coon Creek) from this analysis would yield quite different numerical results. For example, "all project" total benefits would fall to $473,411; total costs would fall to $198,706, and $304,596 at interest rates of r and 6 percent, respectively; and the B/C ratios at these two rates would be 2.39 and 1.55. However, exclusion of Coon Creek would not affect the number of projects with B/C's smaller than 1 or the significance of nonviable projects hidden within a favorable aggregate B/C ratio.

2 The interest rates assumed by the Soil Conservation Service in amortizing project installation costs (See table 4.8).

Table 4.10 Study watershed projects: benefit-cost ratios of wildlife recreation structures and all structures				
	Benefit-cost ratios[1]			
Watershed	Wildlife/recreation structures		All structures	
	r[2]	6 percent	r[2]	6 percent
Rush-Pine Creek	--	--	1.09	0.73
Coon Creek	--	--	16.14	9.65
Middle Fork of Two Rivers	--	--	9.32	5.85
Bear Valley	--	--	1.09	0.68
North Branch of Two Rivers[3]	1.00	0.59	1.32	0.82
Zippel	--	--	2.30	1.51
Crooked Creek	2.00	1.27	1.24	0.67
Crane Creek[3]	1.00	0.65	1.15	0.76
Joe River[3]	1.00	0.64	3.26	2.14
Cooks Valley	1.25	0.82	1.09	0.69
Lakes Okabena and Ocheda[3]	2.97	2.02	2.58	1.73
Tamarac River[3]	1.18	0.80	2.04	1.37
Janesville Village	1.53	0.98	1.93	1.36
Eight watersheds with W/R structures	1.85	1.23	1.92	1.24
All watersheds	1.85	1.23	3.08	1.99

1 Benefit and cost estimates used in computing these estimates are presented in table 4.6 and table B.1 of Daves, "Small Watershed Management."

2 The interest rates assumed by the Soil Conservation Service for amortization of installation costs (See table 4.8).

3 Benefits to wildlife improvements for these projects are assumed equal to annual costs, with installation costs amortized at SCS interest rates, r.

$806,000 annually, remain constant as interest rates are increased. However, annual costs increased from $247,000 at SCS interest rates to $293,000 at 4 percent and $384,000 at 6 percent. Assuming that only projects found economically viable would be approved (i.e. those having benefit-cost ratios at least equal to 1), at a 4 percent rate of interest, eight projects with aggregate annual benefits of $708,000 and aggregate annual costs of $189,000 could be justified. The five projects with benefit-cost ratios of less than 1 have benefits of $98,000 and costs of $103,000. Assuming a 6 percent amortization rate, seven viable projects have aggregate annual benefits of $698,000 and costs of $237,000. The six projects rejected at this interest rate have benefits of $107,000 and costs of $148,000.

Thus if we are willing to assume that 6 percent is a reasonable rate for cost amortization, this analysis indicates that about $148,000 annually (38 percent of annual real costs of drainage and flood control improvements for the 13 approved projects) are allocated to projects estimated to generate a net loss annually of $41,000 in income available for consumption or reinvestment.

4.3.2 Economic feasibility of all structures

To determine the effects on project feasibility of explicitly including fish and wildlife and recreation benefits and costs in project analysis, benefit-cost ratios including these elements were computed (table 4.10). Fish and wildlife benefit estimates were made by SCS for only two of the seven study projects that included structures for these purposes. Therefore, fish and wildlife benefits for the other five projects were assumed. The benefit levels for fish and wildlife structures were assumed equal to estimated annual costs (at SCS interest rates) of these structures.

At SCS interest rates, benefit-cost ratios of fish and wildlife or recreation structures for the eight projects including them ranged from 1 (the assumed ratio) to 2.97. At an interest rate of 6 percent, fish and wildlife and recreation structures for six of the eight proj-

Table 4.11	Study watershed projects: total project benefit-cost ratios including all structural and land treatment measures

Watershed	Benefit-cost ratios[1]					
	$AB_{ltm} = 0$		$AB_{ltm} = \frac{1}{2}AC_{ltm}$		$AB_{ltm} = AC_{ltm}$	
	r^2	6 percent	r^2	6 percent	r^2	6 percent
Rush-Pine Creek	0.10	0.07	0.55	0.38	1.01	0.70
Coon Creek	6.82	4.16	7.10	4.33	7.39	4.51
Middle Fork of Two Rivers	4.06	2.52	4.34	2.70	4.62	2.87
Bear Valley	0.45	0.28	0.74	0.47	1.04	0.65
North Branch of Two Rivers	0.44	0.28	0.77	0.48	1.11	0.69
Zippel	1.34	0.88	1.55	1.02	1.76	1.15
Crooked Creek	0.89	0.51	1.03	0.59	1.17	0.67
Crane Creek	0.65	0.43	0.87	0.57	1.08	0.73
Joe River	1.82	1.19	2.04	1.34	2.26	1.48
Cooks Valley	0.79	0.51	0.93	0.60	1.06	0.68
Lakes Okabena and Ocheda	1.84	1.27	1.99	1.37	2.13	1.47
Tamarac River	1.51	1.02	1.64	1.10	1.77	1.19
Janesville Village	0.75	0.52	1.06	1.73	1.36	0.94
All watersheds	1.72	1.12	1.94	1.26	2.16	1.41

1 Benefit and cost estimates used in computing these ratios are presented in table 4.6 and in table B.1 of Daves, "Small Watershed Management."

AB_{ltm}: Assumed average annual benefits of land treatment measures in excess of those attributed to the projects in project work plans.

AC_{ltm}: Estimated average annual cost of land treatment measures, with installation costs amortized at r. Estimates of installation costs are given in the watershed work plans.

2 The interest rates assumed by the Soil Conservation Service in amortizing installation costs (table 4.5).

ects were found not to be economically feasible.

Costs of fish and wildlife and recreation structures represent only a small part of total project structural costs for the eight projects (about 15 percent at SCS interest rates). Therefore, the impact of including them in total projects analysis is small for most of these projects. For the eight projects collectively, inclusion of wildlife/recreation benefits and costs (at SCS interest rates) in project analysis results in a negligible decrease in the structural measure benefit-cost ratio from 1.92 to 1.91. No change occurs at 6 percent, both with and without ratios being 1.24. However for the Lakes Okabena and Ocheda project, where costs of wildlife and recreation structures comprise more than 65 percent of total structural costs, the wildlife and recreation ratio of 2.97 increases the total project benefit-cost ratio from 1.79 to 2.58.

4.3.3 Including land treatment measures

For the study projects, land treatment costs and benefits were considerably more important as potential sources of error in project evaluation than were the estimates for fish and wildlife or recreation. Required land treatment measures accounted for 44 percent of total project installation costs for the study projects, but costs of these measures were not included in the SCS project analyses. To evaluate the effects of including land treatment costs and any additional benefits, total project benefit-cost ratios were computed assuming their inclusion (table 4.11).

The ratios shown in table 4.11 illustrate the impact on project analyses of including the costs and independent benefits of required land treatment measures. With the assumption that required land treatment measures generate no benefits in excess of those attributed to the projects (columns 1 and 2), at SCS interest rates, seven of the thirteen study projects failed to generate annual benefits equal to the annual costs of all required measures. At an interest rate of 6 percent, only five of the 13 projects were economically feasible. With inclusion of land treatment costs and the assumption of zero independent land treatment benefits, the aggregate benefit-cost ratios for the 13 projects fell substantially. Assuming SCS interest rates, the aggregate ratio fell from 3.08 (see table 4.10) to 1.72 when land treatment costs were included. With a 6 percent rate, the aggregate ratio fell from 1.99 to 1.12.

When land treatment measures were assumed to generate annual independent benefits equal to one-half of their annual costs, at SCS interest rates, five projects had benefit-cost ratios of less than 1, and seven projects were uneconom-

Table 4.12	Study watershed projects: the effects on aggregated benefits and costs of including all structural and land treatment measures in project evaluation					
Item	Rate of interest for amortization					
	r[1]			6 percent		
	Level of independent land treatment benefits[2]					
	a	b	c	a	b	c
All projects (No.)	(13)	(13)	(13)	(13)	(13)	(13)
Total Benefits ($000)	872.6	985.0	1,097.4	872.6	985.0	1,097.4
Total costs ($000)	508.4	508.4	508.4	780.8	780.9	780.8
B/C ratio	1.72	1.94	2.16	1.12	1.26	1.41
Projects with B/C's < 1 (No.)	(7)	(5)	(none)	(8)	(7)	(7)
Total benefits ($000)	153.5	123.1		188.7	213.9	274.4
Total costs ($000)	238.3	151.6		408.1	368.3	368.3
B/C ratio	0.64	0.81		0.46	0.58	0.75
Projects with B/C's ≥ 1 (No.)	(6)	(8)	(13)	(5)	(6)	(6)
Total benefits ($000)	719.0	861.9	1,097.4	683.9	771.1	823.1
Total costs ($000)	270.1	356.8	508.4	372.6	412.5	412.5
B/C ratio	2.66	2.42	2.16	1.84	1.87	2.00

1 The interest rates assumed by the Soil Conservation Service in amortizing project installation costs (See table 4.5).

2 Land treatment measures are assumed to generate independent (of project structural measure) benefits equal to: (a) zero; (b) one-half of annual land treatment costs; and (c) annual land treatment costs. Annual land treatment costs were estimated assuming the same interest rates (r) used for benefit estimation.

ie at 6 percent. Aggregate benefit-cost ratios for the 13 projects were 1.94 at SCS interest rates and 1.26 at 6 percent.

Under the most optimistic assumption made—that land treatment measures annually generate independent benefits equal to their annual costs—all 13 of the study projects were found economically feasible at SCS interest rates. However with an interest rate of 6 percent, seven projects would fail to generate benefits sufficient to cover costs. Aggregate benefit-cost ratios are 2.16 and 1.41 for the SCS and 6 percent interest rates, respectively.

Because of the assumption that land treatment measures must at most generate independent benefits equal to their costs, individual project and aggregate benefit-cost ratios fall when land treatment measures are included. Therefore, it can be concluded that excluding land treatment costs and benefits from project benefit-cost analyses results in inflated benefit-cost ratios if the actual levels of independent land treatment benefits do fall within the range of assumptions made here.[63] Also significant with respect to resource allocation is that inclusion of land treatment measures in project analyses results in substantial shifts in the relative ranking of projects. When compared with the project rankings (by benefit-cost ratios) analyzed at SCS interest rates and without considering land treatment measures (table 4.10, column 3), under each of the land treatment benefit assumptions, eight of the 13 projects shifted in relative position. Similar shifts occurred when a 6 percent interest rate was assumed.

Another perspective on the effects of inclusion of land treatment measures is found in table 4.12. At SCS interest rates and with the low assumption for independent land treatment benefits (0), 47 percent of the total expenditures planned for all projects were found to be allocated to projects that would have benefit-cost ratios less than 1. The net annual loss accruing to these seven nonviable projects would be $85,000. With the assumption that independent benefits equal one-half of costs, almost $152,000 were allocated annually to five nonviable projects with a net annual loss of $28,000. When independent benefits equal

63 More than 50 percent of all land treatment expenditures planned for the study projects were designated for construction of farm or auxiliary drainage ditches which are necessary to obtain project benefits. Although benefits from these measures are included as project benefits, their costs are not included as project costs. Thus, the other required land treatment measures would have to generate independent benefits equal to more than twice their costs for the overall ratio of independent land treatment benefits to costs to be as great as 1. This level of benefits to other land treatment measures is quite unlikely. In a study of SCS conservation plans for 180 farms located in four southern states, Herbert Grubb found that, on a county aggregate basis, positive net benefits would be generated by land treatment practices proposed in only two of 12 study counties. This result was obtained with interest rates ranging from 1 to 9 percent. Furthermore, Grubb found large between-farm differences in net benefit results and concluded that benefit-cost analysis of each individual farm conservation plan would be necessary to insure feasibility of practices proposed for each farm. Grubb, "Benefits and Cost of Soil Conservation in the South," op. cit., pp. 80-83.

to land treatment costs are assumed, each project generated positive net benefits at SCS interest rates.

At 6 percent, the estimated performance of the 13 projects is somewhat worse. With the low benefit assumption, eight projects fail to cover costs. If implemented, these eight would together generate annual net losses of $219,000, more than half of their total costs. Fifty-two percent of total annual costs for the 13 projects is allocated to the uneconomic projects. When independent benefits are assumed to be 50 percent of costs, the seven uneconomic projects have an aggregate benefit-cost ratio of only 0.58 and would yield annual losses of $154,000. Forty-seven percent of total annual costs is attributable to these projects. Given the optimistic assumption that land treatment measures generate benefits equal to their costs, at 6 percent interest seven projects still fail to generate benefits equal to costs. However, because of the higher benefit level assumed, they would generate losses of only $94,000 annually.

Table 4.13 Gross and net benefit-cost ratios for three watershed projects[1]

Watershed	$\frac{B_g - C_e}{C_p}$[2]	$\frac{B_g}{C_p + C_e}$[2]
Middle Fork of Two Rivers	9.32	4.80
North Branch of Two Rivers	1.44	1.31
Joe River	3.28	2.30
Aggregate Ratio	3.78	2.57

1 The data used to compute these ratios are given in table 4.7 and in table B.1 of Daves, "Small Watershed Management."

2 B_g = Gross annual increases in income generated by project and extra-project measures.
C_e = Annual costs of extra-project measures necessary for project success.
C_p = Annual project costs.

4.3.4 Effects of associated cost placement

The effects of including associated costs on the cost side of project benefit-cost ratios instead of subtracting them from gross benefits were calculated for the three projects for which associated cost data could be obtained.[64] For these computations, costs and benefits of land treatment measures were not included. The resulting benefit-cost ratios are given in table 4.13.

The magnitude of the decrease in the benefit-cost ratio for each project is directly related to the percentage associated costs are of total project costs. For the Middle Fork of Two Rivers project, associated costs are 54 percent of total costs and, when shifted to the cost side of the ratio, result in a 48 percent decline in the project benefit-cost ratio. The 45 percent of Joe River costs which are associated costs result in a 30 percent reduction in the benefit-cost ratio when they are included with project costs. Shifting the 31 percent of North Branch of Two Rivers costs, which are associated costs, results in a 9 percent decrease in the benefit-cost ratio.

Had benefits and costs of land treatment measures been included in the ratios, the effects of moving associated costs to the cost side of the ratio would have been reduced somewhat. However, the potential for distortion if associated costs are a large part of total essential project costs is well-illustrated by these three projects. By moving associated costs from the benefit to the cost side of the ratio, the aggregate benefit-cost ratio is reduced from 3.78 to 2.57, a decline of 30 percent. Furthermore, the relative sizes of the benefit-cost ratios change substantially.

64 Associated costs are the costs of required extra-project measures necessary for achievement of project benefits. See the discussion of associated costs in subsection 3.1.1 of Chapter III.

V EVALUATION OF INTRA–WATERSHED AND INTER–WATERSHED DECISIONS

5.1 Planning units and planning components

Four of the five watershed improvement projects evaluated in this chapter are PL 566 watersheds which were included in the analysis described in Chapter IV– the Middle Fork of Two Rivers, North Branch of Two Rivers, Joe River, and Tamarac River watersheds. The fifth project is the Roseau River flood control (and drainage) project proposed by the U.S. Army Corps of Engineers.[65]

65 First evaluated comprehensively in 1940, the Roseau River project has not been approved for installation. Updated in 1963, the project proposal is considered active by the Corps of Engineers. This project was included in the present analysis because its implementation could have important external effects on the other projects studied.

The project areas, watershed districts, and their relation to other geographic and political areas are shown in figure 5.1.

Primary local sponsors for the four PL 566 projects are, respectively, the Two Rivers Watershed District (for both the Middle Fork and North Branch projects), the Joe River Watershed District, and the Marshall County Board of Commissioners.[66] The local cooperator with the Corps of Engineers on the Roseau River project is the Roseau Watershed District.

66 No watershed district has been established in the Middle River Watershed Unit (including the Tamarac River Watershed). Therefore, to enable local interests to perform functions required by PL 566, the Tamarac River was established as a legal county ditch under administration of the county comissioners.

In order to evaluate the efficiency of improvements planned for each watershed project, components which could be implemented independently were identified. Delineation of separable components for the Joe River project was based upon the project map and other descriptive information included in the project work plan. Separable components for the other three PL 566 projects were identified in the project work plans. The Roseau River project was evaluated only as a unit because the benefits generated by particular components were not identifiable. However. planned drainage measures supplemental to the basic Roseau River flood control project were considered separately. The separate components evaluated for the four PL 566 projects are illustrated in figure 5.2.

Figure 5.1 The Red River Valley study area, northwestern Minnesota

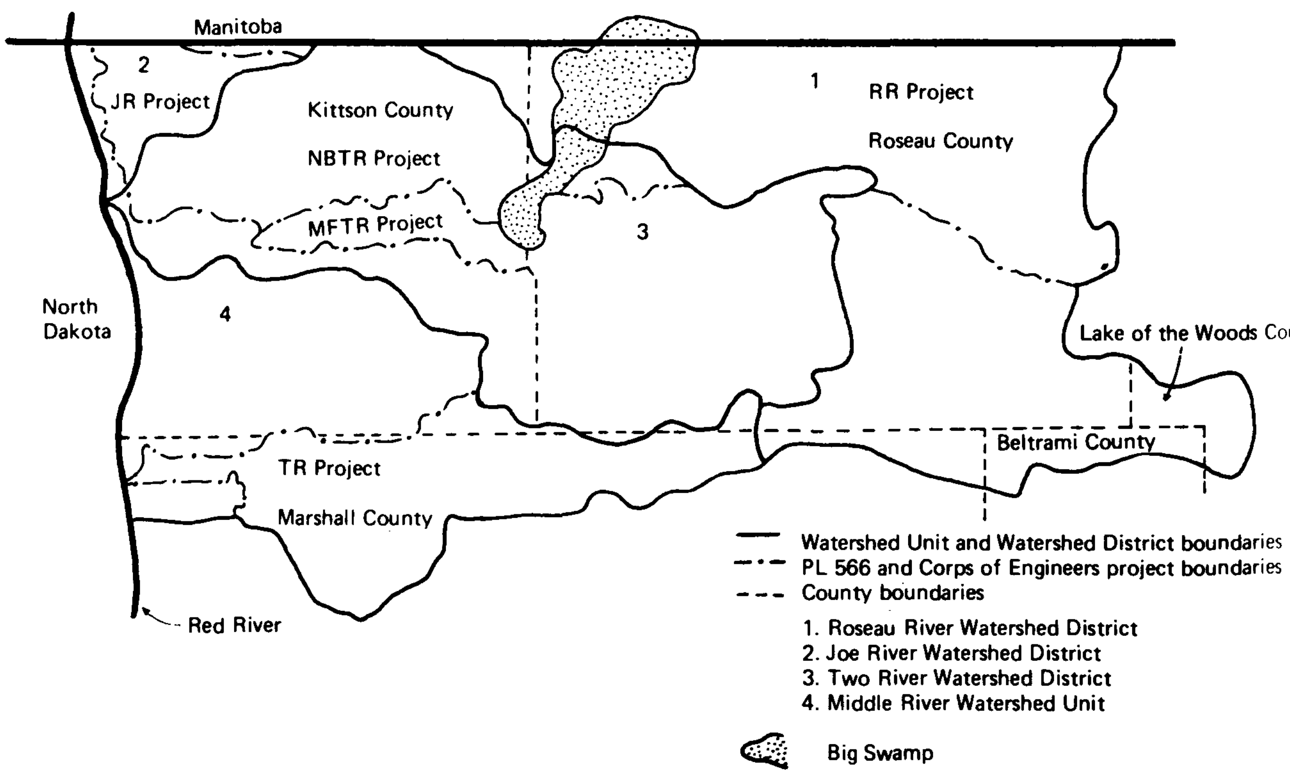
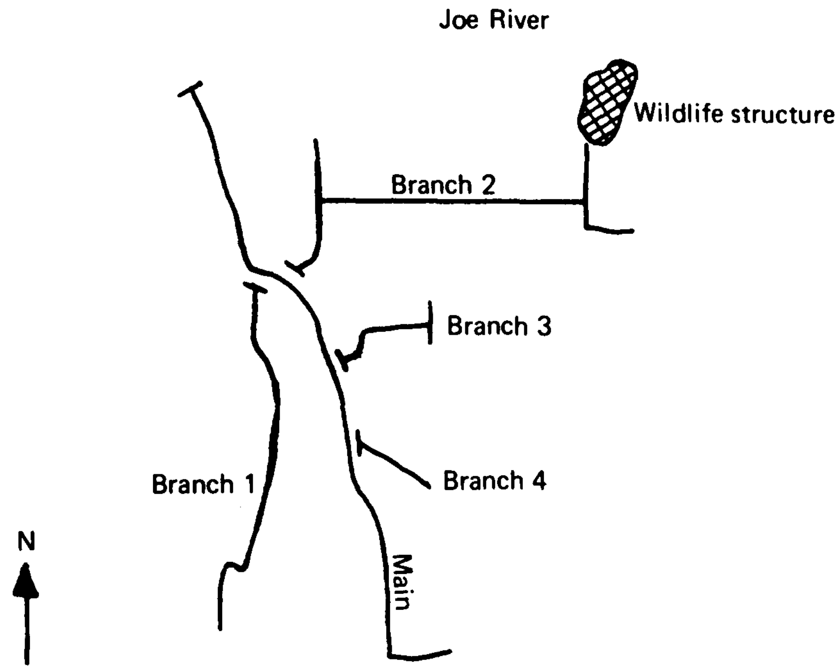


Figure 5.2 Independent project components for four Red River Valley watershed projects



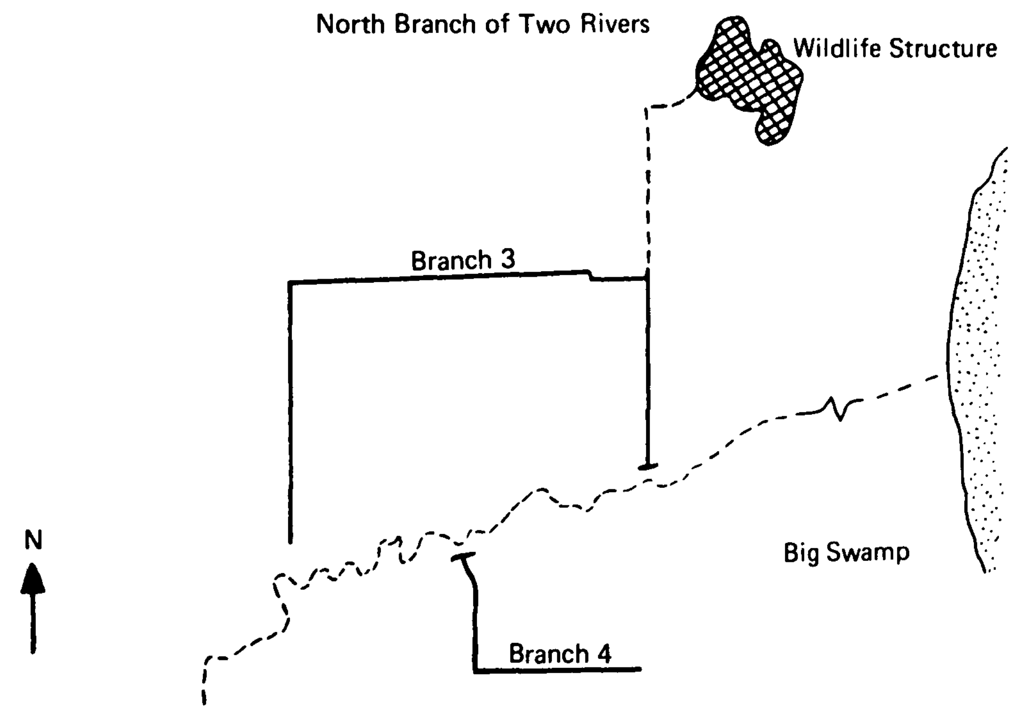
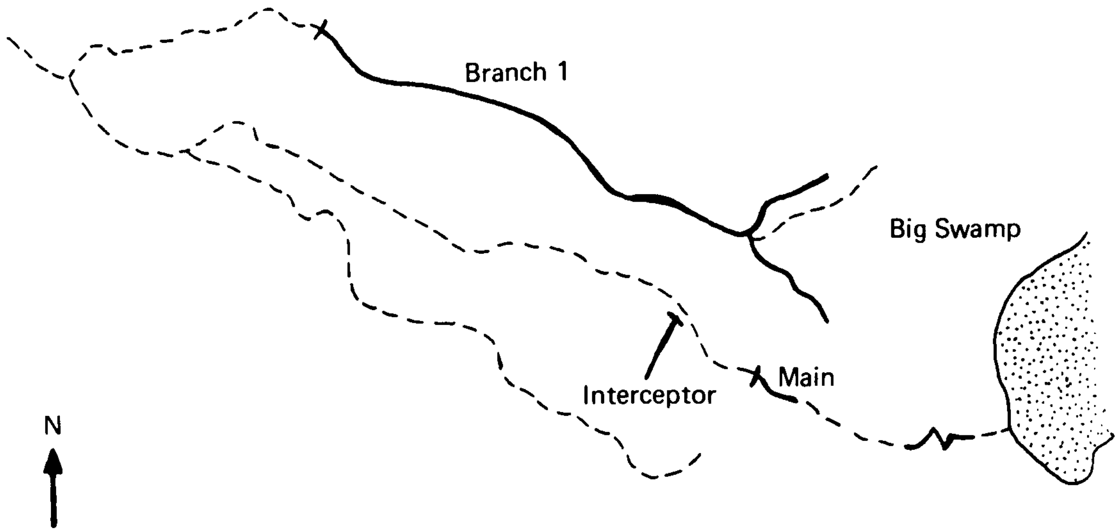
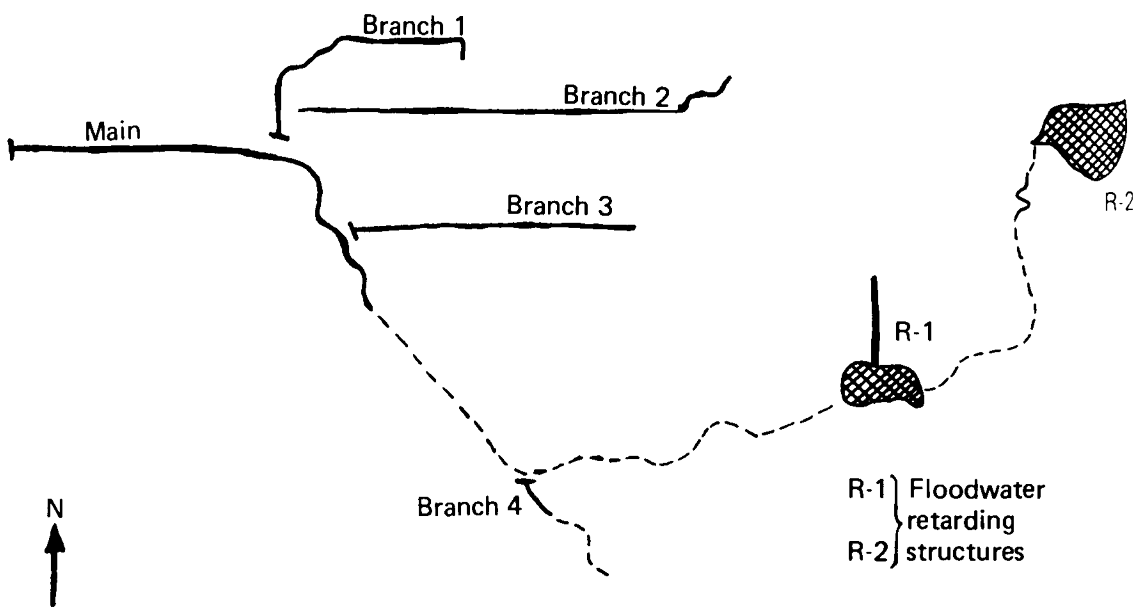


Figure 5.2 Independent project components for four Red River Valley watershed projects, continued

Middle Fork of Two Rivers



Tamarac River



5.2 Component costs

To obtain cost estimates for benefit-cost analysis of individual project components, it was necessary to apportion unassigned installation and operation and maintenance costs among the designated components. Once assigned to particular project components, costs were normalized to a 1957-59 cost base to allow comparison of their expected economic performances. Conversion of costs to a 1957-59 base was accomplished by multiplying nominal costs for each project by a conversion factor developed from the composite construction cost index published by the Department of Commerce.

5.2.1 Installation costs

The costs of installing structural measures for individual project components are given in the work plans of all projects except Joe River. The Joe River work plan lumps all structural installation costs for the five separate channel components planned. To estimate costs for each of the channel components, work plan data were utilized on the volumes of excavation required for each. Total channel improvement costs were distributed among components in proportion to the excavation volume required for each component.

In the watershed work plans, required land treatment measures were not associated with any particular structural measure. However to allow comparison of total costs and total benefits on individual project components, it was necessary to assign installation costs of land treatment measures to particular structural components. The assignment of these costs was made by allocating total land treatment installation costs to structural components in proportion to the effective (i.e. uncontrolled) drainage area above each component. Major tracts of undeveloped land in the headwater areas of the Middle Fork, North Branch, and Tamarac River watersheds were assumed not to require land treatment and were excluded from the estimates of effective drainage areas. Also, no land treatment measures except those explicitly designated in the work plans as being for wildlife purposes were assigned to wildlife structures.

5.2.2 Operation and maintenance costs

Operation and maintenance costs of structural measures for the separate channel improvement components of the Joe River and Tamarac River Projects are not indicated in the project work plans. For this analysis, these costs were estimated by allocating total channel improvement operation and maintenance costs to individual components in the same proportions as installation costs. For nonchannel improvements of these projects and for other projects, operation and maintenance costs are allocated in the respective work plans.

Operation and maintenance costs of land treatment measures were assumed to be 1 percent of land treatment installation costs (see footnote 60).

5.2.3 Annual costs

Total annual fixed costs of the project components were computed by amortizing installation costs over 50 years, assuming interest rates of 3 and 6 percent.[67] The estimates of annual operation and maintenance costs were then added to these totals to obtain total annual costs to the project components.

[67] A 3 percent rate of interest was used for the analysis in this section to eliminate distortions in relative benefit-cost ratios caused by the use of numerous different interest rates in the original (SCS) analyses while at the same time approximating the levels of interest charges used in SCS analyses. Use of a 4 percent interest rate, as was done in the previous analyses of this study, would not allow comparison between the impacts on project feasibility of SCS and higher (6 percent) interest charges.

5.3 Component benefits

Expected annual benefits from structural measures of individual project components given in the Middle Fork, North Branch, and Roseau River project work plans were used in the analysis of these components. Flood control and drainage benefits estimated for structural measures on the Joe River and Tamarac River watersheds were not assigned to particular project components in the project work plans. Therefore, these benefits were estimated in the same manner as costs were allocated, i.e. benefits generated by the separate project components were assumed to be proportional to the effective uncontrolled drainage area above each component.

Annual benefits of fish and wildlife structures were assumed equal to total annual costs of these structures, assuming a 3 percent interest rate. Benefits of the one recreation facility (Tamarac River) were estimated by the Soil Conservation Service and presented in the watershed work plan.

Independent land treatment benefits, in addition to those attributed to structural measures, were estimated at two levels: one-half of total annual land treatment costs; and all of land treatment costs (assuming a 3 percent interest rate).

Because benefits for all projects were originally estimated assuming projected long term prices (see footnote 56), there was no need to normalize benefits to achieve comparable benefit-cost ratios.

5.4 Economic feasibility

In this section, independent project components and purposes are evaluated for economic feasibility using the economic efficiency criteria, (2) and (3), outlined in subsection 1.4.2 of Chapter 1.[68]

[68] For a definition of independence of components and purposes see footnotes 5, 6 and 7 of Chapter 1.

5.4.1 Project components

Benefit-cost ratios for each of the independent components of the study projects are given in table 5.1. Total project ratios and an evaluation of total project feasibility are presented in section 4.3 of Chapter IV. Therefore, the following discussion focuses on the additional information provided on the quality of project planning by the benefit-cost ratios of independent project components. For each component, ratios were developed under four sets of assumptions about the levels of benefits from independent land treatment measures and interest rates.

Land treatment benefits = One-half land treatment costs. With this assumption, most of the project components (19 of 23)

Table 5.1 Project and project component benefit-cost ratios for five Red River Valley watershed improvement projects

Project Component	Benefit-cost ratios[1]			
	a		b	
	3%	6%	3%	6%
Middle Fork of Two Rivers				
Main Channel	0.99	0.67	1.03	0.69
Branch 1	4.29	2.90	4.58	3.10
Interceptor	3.98	2.70	4.35	2.94
Total	4.00	2.70	4.28	2.89
North Branch of Two Rivers				
Branch 3	0.65	0.44	1.01	0.68
Branch 4	0.83	0.56	1.21	0.81
Wildlife structure	1.03	0.65	1.05	0.66
Total	0.77	0.52	1.10	0.74
Joe River				
Main Channel	1.68	1.13	1.85	1.25
Branch 1	2.80	1.88	3.08	2.08
Branch 2	2.10	1.42	2.32	1.56
Branch 3	3.11	2.09	3.43	2.31
Branch 4	3.23	2.17	3.56	2.40
Wildlife structure	1.11	0.73	1.21	0.80
Total	2.14	1.44	2.36	1.59
Tamarac River				
Main Channel	0.62	0.41	0.70	0.47
Branch 1	1.98	1.32	2.35	1.50
Branch 2	1.37	0.73	1.56	0.83
Branch 3	1.21	0.81	1.38	0.92
Branch 4	2.36	1.58	2.70	1.80
Flood-retarding structure–R1	7.68	5.11	7.80	5.18
Flood-retarding structure–R2	4.51	3.00	4.51	3.00
Recreation facility–F1	1.41	0.97	1.41	0.97
Wildlife facility–F2	1.08	0.70	1.17	0.75
Total	1.86	1.20	2.00	1.29
Roseau River				
Main Channel	2.35	1.49	2.35	1.49
Supplemental works	2.95	2.12	2.95	2.12
Total	2.71	1.85	2.71	1.85

[1] Cost and benefit estimates used in calculating these ratios are given in appendix tables B.2 and B.3 of Daves, "Small Watershed Management."

a- independent land treatment benefits equal one-half of annual land treatment costs (3 percent interest rate).

b- independent land treatment benefits equal annual land treatment costs (3 percent interest rate).

3% installation costs amortized assuming a 50-year project life and 3 percent interest rate.

6% installation costs amortized assuming a 50-year project life and 6 percent interest rate.

were found viable given a 3 percent rate of interest. At 6 percent interest, 10 of the 23 components failed to generate benefits equal to costs.

Interest rate = 3 percent. With installation costs amortized at 3 percent interest, the main channel improvement of the Middle Fork project and both channel improvement components planned for the North Branch project would be rejected. The main channel improvement for Tamarac River also had a benefit-cost ratio of less than 1.

However, planned improvements to Branches 1, 2, and 3 of Tamarac River would require main channel improvement in order to obtain full benefits. Therefore, main channel improvements downstream from each of these branches were assumed to be an integral part of the respective branches. That is, Branch 1 could be effectively implemented only if the 62 percent (by length) of the proposed main channel improvement which lies downstream was also implemented. Similarly, Branch 2 would require 62 percent and Branch 3 would require 83 percent of the main channel improvement to be completed. Thus, only the upper 17 percent of the proposed main channel improvement could be considered independently of other project measures.

By combining the benefits and costs of the part of the main channel that provides an outlet to Branch 1 with benefits and costs of this branch, a benefit-cost ratio greater than 1 was obtained. Similarly, including costs and benefits of necessary downstream improvements, the costs and benefits of Branch 2 yield a benefit-cost ratio greater than 1. But the additional 21 percent of the main channel necessary as an outlet to Branch 3 brings that channel's ratio below 1. Therefore given the several assumptions stated, the Branch 3 improvements and 38 percent of the main channel improvements planned for Tamarac River would be rejected. These components would generate net losses of $8,000 annually if implemented.

Interest rate = 6 percent. With installation costs amortized at 6 percent, additional components found not economically feasible included the planned wildlife structures for the North Branch and Joe River projects, Branch 2 and Branch 3 improvements, and the wildlife and recreation facilities planned for Tamarac River. Also, the Branch 1 component of the Tamarac River project was not viable if combined with the necessary main channel improvements downstream. Altogether, the nonviable components at 6 percent had annual costs $50,000 greater than annual benefits.

Land treatment benefits = land treatment costs. With this more liberal assumption with respect to land treatment benefits, only one project component was found not viable at 3 percent interest. However at 6 percent, the 10 components rejected under the alternative benefit assumption (discussed earlier) were found to have benefit-cost ratios less than 1.

Interest rate = 3 percent. With installation costs amortized at 3 percent, only the main channel of Tamarac River had a benefit-cost ratio less than 1. But when benefits and costs of the part of this improvement below Branch 3 were combined with those of Branches 1, 2, and 3, the overall ratio was greater than 1. Thus only that portion of the main channel above Branch 3, 17 percent of the total main channel improvement, would be rejected. Implementation of this segment would yield a net annual loss of $1,460.

Interest rate = 6 percent. With installation costs amortized at 6 percent, all of the components rejected at 6 percent with the lower benefit assumption were again rejected. Branch 1 of Tamarac River was also found nonviable when combined with downstream main channel improvements. Annual losses generated by the nonviable components would total $31,000.

Implications. This analysis indicates that a number of independent components approved for installation in the study watershed would not be economically viable with the inclusion of land treatment benefits in the analysis and with the assumption of slightly more realistic interest rates. Total project benefit-cost ratios, which are often the only specific benefit-cost information given to the decisionmakers, obscure information which should enter the decision process. For example, the fact that more than 40 percent of total benefits but only about 13 percent of total costs for the Tamarac River project are attributable to the project's two flood retarding structures would be useful information to decisionmakers, particularly in view of the project's relatively poor overall benefit-cost ratio (between 1.20 and 1.29 when a 6 percent interest rate is assumed).

It is the stated procedure of PL 566 planners (SCS) to analyze separately the economic viability of all project components which can be constructed separately, taking into account the external effects of each component's implementation or lack of implementation. However, both the Joe River and Tamarac River projects were evaluated as single structural units. As figure 5.3 illustrates, there appear to be several readily separable, independent units in each of these projects. Given the longstanding efforts to promote drainage in northeastern Minnesota, often with uneconomic consequences, failure to evaluate drainage elements separately suggests that these projects may be dressed up drainage projects.

5.4.2 Project purposes

Wildlife/recreation. Referring to tables 4.10 and 5.1, it is apparent that, if the benefit estimates made are reasonable, the wildlife and/or recreation improvements included in these projects are not good investments for society. Eight of the PL 566 projects evaluated in Chapter IV include wildlife/recrea-

Table 5.2 Costs and benefits of the flood control and drainage elements included in four Red River Valley watershed projects (1957-59 dollars)					
Project Purpose	Amortization (6%)	Annual costs[1] Operation & maintenance	Total	Annual benefits[2]	Benefit-cost ratio
		(thousand dollars)			
Middle Fork of Two Rivers					
Flood control	5.2	0.9	6.1	26.2	4.29
Drainage	11.6	2.0	13.5	30.7	2.26
Total project element	17.8	2.9	19.7	56.9	2.89
North Branch of Two Rivers					
Flood control	12.8	2.2	15.0	11.5	0.77
Drainage	17.1	2.7	19.9	14.5	0.73
Total project element	29.9	4.9	34.8	26.0	0.75
Joe River					
Flood control	33.1	5.7	38.9	86.4	2.22
Drainage	32.5	5.2	37.7	35.8	0.95
Total project element	65.7	10.9	76.6	122.2	1.60
Tamarac River					
Flood control	80.9	11.3	92.2	127.2	1.38
Drainage	25.0	3.8	28.8	24.1	0.84
Total project element	105.9	15.1	121.0	151.3	1.25

1 Costs of structural measures are apportioned between flood control and drainage in the watershed work plans. Land treatment costs not explicitly allocated to drainage in the watershed work plans were allocated between flood control and drainage in proportion to the ratios of apportioned costs for each of the two purposes to total apportioned costs.

2 Annual independent benefits of land treatment measures are assumed to be equal to annual land treatment costs with a 3 percent interest rate. These benefits are allocated between flood control and drainage in the same manner as costs (See footnote 1 above). Structural measure benefits for the two purposes were taken directly from project work plans.

tion structures. At a 6 percent interest rate, only two of the eight had wildlife or recreation benefit-cost ratios greater than 1. Significantly, for the five projects with direct estimates of wildlife or recreation benefits, these project elements had benefit-cost ratios of less than 1 in three out of the five cases when an interest rate of 6 percent was used (table 4.10).

The component analysis summarized in table 5.1 includes land treatment benefits associated with the wildlife and recreation improvements that were evaluated. Results here were similar. With interest rates at 3 percent, each of the four wildlife and recreation elements evaluated was viable. With a 6 percent interest rate, none was viable.

Flood control and drainage. In Chapter IV, flood control and drainage structures included in the 13 study projects were evaluated for economic feasibility. At an interest rate of 4 percent, flood control and drainage structures planned for five of the projects were found to have benefit-cost ratios less than 1. With benefits and costs annualized at 4 and 6 percent, respectively, these structures planned for six of the projects had benefit-cost ratios less than 1.[69]

To supplement the analysis of Chapter IV which combined flood control and drainage measures as single units, benefits designated as being for flood control and for drainage in four project work plans were separated and compared with the costs attributed to these purposes.[70] Results are given in table 5.2.

The benefit-cost ratios obtained show that the flood control and drainage element for only one of these projects, North Branch, is not economically feasible under the specified conditions. However, planned drainage measures for two other projects also have benefit-cost ratios less than 1, and the ratio for drainage measures of the fourth project is only about half the ratio for flood control measures for that project.

The relatively poor performance of drainage measures can be explained, in large part, by the na-

69 See table 4.8 and the accompanying discussion in section 4.3.1, Chapter IV.

70 The Roseau River project was not included in this analysis because, although the channel improvement for flood control is independent of the supplemental works (for drainage), these works would have negative effects if implemented without completion of the channel improvement.

ture of drainage improvements. Of total installation costs of drainage measures for the four projects, more than 80 percent were costs of required land treatment measures. By comparison, for flood control measures, land treatment accounted for only 15 percent of total installation costs. High proportions of land treatment costs to total costs for drainage measures bring about low benefit-cost ratios. If land treatment costs and independent benefits were not included in project analysis (as is now the rule for PL 566 projects), both flood control and drainage measures would have much higher benefit-cost ratios. And drainage measures for these projects would show relatively higher benefit-cost ratios.

Implications. Only two direct estimates of wildlife benefits were made for the small watershed plans evaluated in this study. However, each of those measures had benefit-cost ratios less than 1 when a 6 percent interest rate was used. This result indicates that the wildlife benefit assumption used in PL 566 project planning—that wildlife improvements are economically feasible if local interests agree to bear half their costs—is not universally valid. More direct estimation of wildlife benefits, however rough, would at least cause project planners to look more critically at proposed wildlife measures and at other project elements which would enhance or destroy wildlife habitat.

Conclusions with respect to planning of recreation development must also be drawn cautiously. Only three recreation elements were included in the watershed projects studied. When analyzed at 6 percent, two of these had benefit-cost ratios greater than 1. This is a somewhat better performance than that exhibited by all project elements—at 6 percent interest, the flood control and drainage elements for only 7 of 13 projects are feasible (table 4.8).

The analysis in Chapter IV of flood control and drainage elements of approved PL 566 projects indicates that, at an interest rate of only 4 percent, more than one-third of the expenditures for these purposes would not generate benefits as large as costs (table 4.8). Furthermore, when required land treatment measures were included in the analysis (tables 4.11 and 4.12), as much as 50 percent of total expenditures were allocated to project elements with benefit-cost ratios less than 1.

In this chapter, the independent evaluations of flood control elements and of drainage elements suggest that a substantial portion of the noneconomic expenditures approved for small watershed projects may arise from the inclusion of extensive onfarm and auxiliary drainage works. These are exempt from economic evaluation by administrative decision of the U.S. Department of Agriculture.

5.5 Optimal planning solutions

This section works out optimal allocations of capital among the 23 components of the five Red River Valley watershed projects. Two different levels of capital availability and three sizes of planning unit are assumed. The capital restrictions serve to force choices among components and to illustrate the different planning solutions obtained with each size of planning unit.

The capital assumptions used were: (a) available capital is 80 percent of the total needed to implement all 23 components planned for the study projects; and (b) available capital is 50 percent of the total needed to implement all planned components. These capital assumptions are not intended to represent specific levels of capital availability which might be expected to occur. However, the 80 percent assumption would correspond to about a 30 to 40 percent cut in PL 566 funds available for small watershed development in Minnesota. Given the current climate for reduction of federal spending, this is probably not an unreasonable assumption. The 50 percent assumption roughly corresponds to the share of total costs now borne by local project participants.[71] For the computation of component costs to determine capital requirements, an interest rate of 3 percent was used.[72]

The sizes of planning units assumed were: (1) the small watershed project area, (2) the area designated as a "watershed unit" in the <u>Hydrologic Atlas of Minnesota</u>,[73] and (3) the total study area encompassing all proposed projects and components. Geographic boundaries of the various planning units are shown in figure 5.1.

The procedure for obtaining planning results under each set of assumptions was to determine the proportion of each proposed component which would be implemented with the given capital and planning unit size restrictions. Relative benefit-cost ratios served as decision criteria for capital allocations. The independent component having the highest benefit-cost ratio within a given planning unit was the first component selected for implementation within that unit. Subsequent components were selected in order of their benefit-cost ranking until capital available to the planning unit was exhausted or until less than 50 percent of the marginal component could be implemented with available capital. This latter restriction was imposed to account for technical indivisibilities of structural components. Unused capital was declared surplus, not available to other planning units.

Results obtained in this analysis are given in table 5.3.

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71 Refer to table 4.2, keeping in mind that about one-half of total land treatment costs are met by federal ACP payments to farmers.

72 Three percent interest was used because it approximates the rates used in the original project evaluations and because, when combined with an assumed level of independent land treatment benefits equal to total land treatment costs, it allows all proposed components to enter the decision process (i.e., to have B/C $\geq$ 1). At 6 percent interest, 11 of the 23 separate components of the study projects—including all three components of the North Branch project—are not viable. Therefore, using a 6 percent interest rate for this analysis does not illustrate very well the effects of changing planning unit size.

73 <u>Loc. cit.</u>

Table 5.3 Red River Valley study area: results of project planning with planning on project watershed unit, and on areawide bases, assuming different levels of capital availability

Structural component	Benefit-cost ratio	Proportion of component implemented[1]					
		80 percent capital availability			50 percent capital availability		
		1	2	3	1	2	3
					(percent)		
Two Rivers Watershed Unit							
MFTR Main channel	1.03	0	0	0	0	0	0
MFTR Branch 1	4.58	100	100	100	63	100	100
MFTR Interceptor	4.35	0	100	100	0	100	100
NBTR Branch 3	1.01	55	0	0	0	0	0
NBTR Branch 4	1.21	100	72	0	100	0	0
NBTR Wildlife structure	1.05	100	0	0	0	0	0
JR Main channel	1.85	58	100	100	58	84	58
JR Branch 1	3.08	100	100	100	85	100	100
JR Branch 2	2.32	96	100	100	0	0	0
JR Branch 3	3.43	100	100	100	100	100	100
JR Branch 4	3.56	100	100	100	100	100	100
JR Wildlife structure	1.21	0	100	100	0	0	0
Middle River Watershed Unit							
TR Main channel	0.70	62	62	0	0	0	0
TR Branch 1	2.25	100	100	0	0	0	0
TR Branch 2	1.56	100	100	0	0	0	0
TR Branch 3	1.38	0	0	0	0	0	0
TR Branch 4	2.70	100	100	100	100	100	0
TR Flood retarding structure—R1	7.80	100	100	100	100	100	100
TR Flood retarding structure—R2	4.51	100	100	100	100	100	100
TR Wildlife facility—F2	1.17	100	100	0	100	100	0
Roseau River Watershed Unit							
RR Main channel	2.34	100	100	100	100	100	100
RR Supplemental works[2]	2.95	66	66	100	16	16	41
Total annual costs		367,539	367,551	369,301	213,130	214,055	230,245
Total annual benefits		927,752	935,843	1,033,839	556,505	582,421	669,105
Aggregate benefit-cost ratio		2.52	2.55	2.80	2.61	2.72	2.91
Annual capital surplus[3]		1,853	1,841	91	17,115	16,190	0

1 These results were obtained using data given in appendix tables B.2 and B.3 of Daves, "Small Watershed Management." The interest rate used is 3 percent. Independent land treatment benefits are assumed to be equal to total annual land treatment costs. Capital available annually is assumed to be: (a) 80 percent; and (b) 50 percent of the total necessary to fully implement all project components. Size of planning units assumed are:

1 Each project is planned separately and must operate within its capital budget.
2 Each watershed unit is planned separately.
3 All project components are planned together (i.e. areawide planning) and available capital can be freely allocated to the component (s) yielding highest returns.

2 All of the main channel improvements must be completed before any of the supplemental works can be effectively implemented.

3 A surplus occurs under some situations because it is assumed that no part of a structural component will be implemented unless at least 50 percent of it can be implemented. The supplemental works of the Roseau River Project were exempt from this assumption because they are all land treatment measures and, hence, more likely to be divisible.

5.5.1 Eighty percent capital availability

Thirteen of the 23 components experienced changes in percentage implementation as size of planning unit increased from small watershed to areawide. Only two components received no funds under any sized planning unit: the main channel of Middle Fork (B/C = 1.03); and Branch 3 of Tamarac River (B/C = 1.11 when combined with necessary main channel outlet improvements). Nine components were fully funded under each planning unit assumption. With planning on a small watershed basis, the reduction of capital available by 20 percent (100 percent to 80 percent) resulted in two components dropping out of the Middle Fork plan, one out of Joe River. and one out of Tamarac River In addition, one component each of the North Branch, Tamarac River, and Roseau River projects and two Joe River components were less than fully implemented (compare columns 1 and 2 of table 5.3). Of the three watershed units studied, only Two Rivers includes more than one project, so, when size of the planning unit was increased from a small watershed project to watershed unit basis, change in capital allocation occured only in that unit. Within the Two Rivers unit, capital was diverted from the three components of the North Branch project (composite B/C = 1.10) to allow implementation of the Middle Fork interceptor and the Joe River wildlife structure and to provide full funding for two other Joe River components with higher benefit-cost ratios. The resulting optimal solution for the Two Rivers watershed unit included eight fully implemented components, one 72 percent implemented and three—with benefit-cost ratios of 1.01, 1.03, and 1.05—not funded. All capital available to the unit was used.

With areawide planning, all components entered a single decision process, and substantial shifting of capital from less efficient to more efficient components occurred. All funds allocated to components of the North Branch project and most of those for Tamarac River channel improvements were shifted to higher return uses. The optimal solution obtained included 14 fully implemented components, the poorest of which had a benefit-cost ratio of 1.21. The nine components excluded from the optimal solution had benefit-cost ratios ranging from 1.01 to 1.34. The component with the 1.34 ratio, Branch 1 and necessary downstream main channel improvements of Tamarac River, was not included because it required $30,000 annually for implementation. The poorest component implemented, the Joe River wildlife structure, required an annual outlay of only $455.

In aggregate terms, moving from project to watershed to areawide planning resulted in substantially improved expenditure allocations with the major improvement occuring with the change from watershed to areawide planning. Aggregate benefit-cost ratios for the three planning unit sizes were, respectively, 2.52, 2.55, and 2.80. The overall increase in annual net benefits as planning unit size increased was $104,000. Unused capital declined from $1,853 to $91.

5.5.2 Fifty percent capital availability

As would be expected, optimal planning solutions obtained under each size of planning unit assumption were quite similar with 50 percent capital availability to those obtained with 80 percent availability. But because of the more stringent capital limitation, more components with low benefit-cost ratios were omitted from optimal plans—nine components received no funding at all under any size of planning unit assumption. Consequently, the aggregate benefit-cost ratios were higher under each size of planning unit assumption. These ratios were 2.61, 2.72, and 2.91 in order of planning unit size. Also, relative increases in total annual benefits were somewhat higher as size of planning unit increased. As the planning unit was increased from project to watershed unit size, total benefits increased 5 percent (1 percent with 80 percent availability). With the change from watershed unit to areawide planning, the increase was 15 percent (10 percent with 80 percent availability). The annual unused capital was more than $17,000 with project-by-project planning and more than $16,000 with watershed unit planning. With areawide planning, all capital was utilized.

5.5.3 Implications

Comparison of results obtained with watershed improvement planning under each of the size of planing unit assumptions indicates superiority for larger planning units measured in terms of efficiency of capital allocation. Under both capital assumptions, aggregate benefit-cost ratios, gross benefits, net benefits, and degree of capital utilization increased with size of planning unit. Each of these changes indicates improved capital allocation.

Extending this analysis by inspection of the component benefit-cost ratios (table 5.3), it can be seen that—with planning on an even smaller unit basis, i.e. component by component—inefficiency in capital allocation is greater than with planning on a watershed basis. If each component suffers an equal reduction in funds, both components with high benefit-cost ratios and those with low ratios can be partially implemented. Obviously, if a capital limitation does exist, a planning unit which allows transfer of funds from low return to high return uses results in higher total benefits per unit of available capital than is obtainable when no transfer is possible.

Several factors which affect efficiency in the use of available capital were not considered in this analysis. Factors which would probably increase the demonstrated superiority of larger planning units include: (1) reduction in duplication of sampling and economic projections in similar and adjacent small watersheds: (2) reduction of administrative costs through consolidation of local sponsor organizations: (3) increases in unit financial base which might allow use of more professional planning services. The first two factors probably would not be of great importance in their effects on efficiency of capital use. For most projects, economic investigation and analysis costs are a very small proportion of total project costs. And, local sponsoring agencies—particularly those in rural areas—usually have few paid employees. Often they don't even have rented office space. However, the third factor might be quite important. With more local planning funds, overall improvements plans (such as those of watershed districts) might be made more useful. Local planning, which is now often "one-shot" and of generally poor quality, could be made continuing and more specific with respect to watershed potentials, problems, and improvement alternatives. Improved planning should result in better returns to watershed improvements expenditures.

The primary factor which might decrease efficiency as planning unit size is increased would be the costs in lost production caused by delaying implementation of any improvements until all are planned and evaluated. Broader planning would undoubtedly take more time than does the planning of single small projects.

Although the net effect of these factors is not obvious, it is doubtful that the indicated improvement in allocation decisions with increased size of planning unit would be reversed by their combined impact.

VI CONCLUSIONS AND RECOMMENDATIONS

The general hypothesis guiding this study was that, because of their legal, political, and operational characteristics, institutions involved in watershed planning in Minnesota are unable (or unlikely) to arrive at public expenditure decisions that are economically efficient. The objectives were: (1) to test this hypothesis by evaluating the procedures used and the results of planning; and (2) to suggest changes in institutional structures and procedures which would make possible or facilitate improved decision-making performance.

The analyses carried out in achieving the first objective (testing the hypothesis) are reported in Chapters III, IV, and V. These include theoretical criticisms of watershed planning assumptions and prodecures (Chapter III); application of changes suggested by the theoretical arguments to the analyses performed (by SCS) for all 13 Minnesota projects which have been approved for construction under the PL 566 program (Chapter IV); and testing for economic efficiency of investment allocations to and among separable components of five projects planned for three contiguous minor drainage basins tributary to the Red River of the North (Chapter V).

Results of these analyses indicate that:

1. Interest rates used in developing the work plans for the study projects (2 1/2 to 3 1/8 percent) are too low to reflect the real opportunity costs of capital. And when a slightly higher rate—4 percent—is assumed, five of the 13 projects accounting for 37 percent ($1,900,000) of the total initial investment for watershed structural measures approved under PL 566 in Minnesota are found not economically viable. With interest at 6 percent, six projects are not viable.

2. Failure of the watershed planners to include wildlife and recreation elements and land treatment measures in project analysis results in inflated benefit-cost ratios, approval of economically nonviable projects, and distortions of the economic comparability of competing projects. Inclusion of all project elements in the reevaluation of the study project work plans (from which they were originally excluded) resulted in the rejection (B/C's < 1) of five of the 13 projects even with the SCS interest rates. Also, the aggregate benefit-cost ratio fell from 3.26 to 1.94, and eight projects shifted in relative position when ranked by benefit-cost ratios.

3. The use of net benefit-cost ratios (increased costs of farm production necessary to achieve full project benefits are subtracted from total benefits) instead of total benefit-cost ratios obscures the real economic efficiency of projects—the ratio of total benefits to total resources expended. The net ratio favors the development of projects having a large proportion of total costs classified as associated costs. Analysis of the three projects for which sufficient data were available indicated reductions of 9, 30, and 48 percent in the estimated project benefit-cost ratios when associated costs were not subtracted from benefits [but] were included. The 48 percent reduction was for the project with the largest proportion (54 percent) of total costs as associated costs.

4. Some project work plans failed to identify and independently test separable project components. Even for those projects with relatively high overall benefit-cost ratios, some planned components were not viable. Of the 18 independent components analyzed, eight are not viable at 6 percent interest, although the projects of which they are parts are. The project with the highest total-project benefit-cost ratio (2.70) at this interest rate has one independent component with an estimated ratio of only 0.67.

5. Aggregate benefits obtainable from a given quantity of investment capital increase as planning unit size is increased, thereby allowing more efficient capital allocation. With capital availability assumed to be 80 percent of the total necessary to implement all 23 separable components of the Red River Valley study projects ($369,000), total annual benefits increased from $928,000 to $936,000 as planning units were increased from project to watershed size. Benefits increased to $1,034,000 when the assumed planning unit size was the total study area. The aggregate benefit-cost ratio for the 23 components increased with planning unit size from 2.52 to 2.55 to 2.80. Similar results were obtained when available capital was assumed to be 50 percent of that required to implement all project components. Total benefits increased by 20 percent as the planning unit was increased from single project to areawide size, and the aggregate benefit-cost ratio increased from 2.61 to 2.91.

6. Watershed districts, the agencies with primary responsibility for small watershed management in Minnesota, have adequate authority to perform most small watershed development and management functions. They are not limited in size by law and , hence, could be made large enough to provide effective areawide planning. They are authorized to exercise eminent domain, to levy ad valorem and special assessment taxes, to regulate resource use, and to cooperate with other government units.

In only two respects does their authority appear to be too limited. They are limited to a maximum of $60,000 of general planning funds. All other planning fund capability is authorized only for specific project planning. Except for improvements with general benefits to the whole district, they cannot initiate improvements or projects unless they they have received formal application from affected parties. These two restrictions effectively limit the quantity and quality of overall planning by watershed districts and force them to maintain a passive role in watershed development. Therefore, these districts often serve only to administer PL 566 projects without having a significant role in project initiation, in planning, or in coordination with other projects. District overall plans are, in general, not specific enough to allow performance of this latter function.

Watershed districts also fail to plan effectively for other reasons. Some Minnesota watershed districts have been created after planning for a PL 566 project was already in progress; the district overall plan was made to fit the PL 566 project rather than the project being designed to fit the district's plan. By Minnesota law, watershed districts can only be created in response to a petition by parties from within the prospective district. And the SCS, in their schematic diagram of PL 566 project planning, calls for applications for watershed districts late in the planning process—after the PL 566 project work plan has already been approved. Also, some existing watershed districts are coincident with a single PL 566 project area and serve no other function than to administer the project.

6.1 Conclusions

On the basis of these summarized results, it can be concluded that the general hypothesis of this study is valid. Because of their legal, political, and operation characteristics, institutions involved in watershed planning in Minnesota are unable (or unlikely) to arrive at public expenditure decisions which are economically efficient. Watershed planning has resulted in substantial misallocation of investment capital. About one-half of the total investment in small watershed development in the state within the past 15 years has been for project components or entire projects which will not yield benefits to society equal to their opportunity costs. (And, because the primary reasons for this capital misallocation are the institutionalized PL 566 project planning assumptions and procedures, it might be expected that results have been similar in other states where PL 566 also plays a predominant role in small watershed planning and development.)

Also, the State of Minnesota and the local communities have failed to perform in their own best interests in watershed management.

While willingly accepting PL 566 program assistance, they have failed to create an institutional structure adequate to control or coordinate PL 566 planning within the state. Watershed districts could be effective planning agencies for comprehensive and efficient development of small drainage basins. However, these districts have often been created too late, are often too small, and have not had enough planning funds to play their potential role.

Finally, it is evident that substantial gains in resource allocation efficiency could be achieved by making a few rather simple changes in the SCS planning guidelines for PL 566 projects. Still further gains could be achieved by improving the capabilities and performance of watershed districts as watershedwide planning agencies.

6.2 An improved system

The second study objective was to suggest changes in the law, institutions, and planning procedures which might overcome the deficiencies and limitations in watershed management and enable improved decisionmaking. Below are some suggestions derived from the preceding analyses.

6.2.1 The Law

Although PL 566, the Watershed Protection and Flood Prevention Act, provides the basic authorization for federal participation in small watershed development, none of the problems identified by this study arises directly from its provisions. Therefore, no changes in the basic act are suggested.

The Minnesota Watershed Act does not survive unscathed. Changes in two particular provisions of this Act are indicated by the analyses and results of this study.

1. The requirement of local application for establishment of a watershed district has, in numerous cases, resulted in a district being applied for and approved only after substantial planning for a PL 566 project has been completed. Problems created by this requirement might be eliminated by: (a) legislative creation of watershed districts throughout the state, perhaps according to boundaries of the small drainage basins or "watershed units" identified in the Minnesota Hydrologic Atlas;[74] or (b) requirement that a watershed district of small drainage basin size be active, with a good specific overall plan, in a particular area before any applications for PL 566 project planning assistance could be approved by the State Soil Conservation Committee.
2. The $60,000 maximum limitation on watershed district organization and planning funds may seriously hinder the development of good overall district plans, particularly for larger districts. This maximum limitation could be made flexible by setting only a maximum mill rate on assessed valuation of real property within the district.

The provisions of the Drainage Code of Minnesota, which authorize the creation of county and judicial ditches, allow circumvention of the coordinated planning which could be achieved by watershed districts, given the adjustments suggested above. It may be necessary to stop the creation of these types of ditch systems in order to achieve adequate planning of small drainage basins.

6.2.2 Planning agencies

As stated earlier, the agencies with the principal responsibility for watershed planning in Minnesota are the watershed districts. These districts have sufficient powers under current law to perform this function, if they were able to obtain enough planning funds. Several established districts are not large enough to perform total watershed (small drainage basin) planning. These districts should be expanded or absorbed by other districts. And all districts created in the future should be large enough to allow coordination of planning on a watershedwide basis. They should all be established, with specific overall plans, well before initiation of individual project planning.

Changes in other institutions involved in small watershed planning are probably not necessary to achieve effective planning. However, the professional planners for PL 566, i.e. SCS personnel, should be made aware that the potential role of watershed districts is something more than facilitating or administrative agencies for established PL 566 projects.

6.2.3 Planning procedures

Changes in project planning procedures, which are necessary if efficient investment allocation in small watershed development is to be achieved, have been outlined numerous times throughout the previous chapters. Briefly, suggested changes are:

1. Interest rates used in estimating costs and in discounting should reflect true opportunity costs and time discount rates of society as accurately as possible.
2. All elements of proposed projects should be subjected to economic analysis and included in total project evaluation.
3. The benefit-cost criterion used in evaluating projects and project elements should reflect the total benefits to society which would be generated per dollar of investment capital allocated to a particular project or element.
4. Whenever adjacent projects have external effects upon each other, they should be planned jointly.

These procedural changes would improve analysis of the economic feasibility of proposed small watershed projects. Even without desirable legal and institutional changes, better analysis could yield substantially better watershed investment decisions.

[74] Loc. cit.

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Technical Bulletin 295–1974
Agricultural Experiment Station University of Minnesota