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TOWARD EFFICIENT AND EQUITABLE WATER ALLOCATION IN MINNESOTA:

A REPORT ON WATER ALLOCATION OPTIONS AND APPROACHES

Prepared for the:

Supply, Allocation and Use Work Group

Minnesota Water Planning Board

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PREFACE

The following paper has been prepared as a detailed background report for use in development of the Framework Water and Related Land Resources Plan. The Plan is be prepared under the direction of the Minnesota Water Planning Board. Funds for the project and the project Work Plan were approved by the Legislative Commission on Minnesota Resources.

The Framework Water and Related Land Resources Plan project is an interagency activity, directed by the Board. Reports in the "technical Paper" services are prepared for interagency work groups by staff persons in one or more agencies. The final "Technical Paper" is a joint project and does not necessarily reflect the views of the agencies represented by the individual preparers.

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They are commended for their efforts.

The paper has been reviewed by and benefited from comments of the Supply, Allocation and Use Work Group of the planning project; the Water Planning Board Technical Committee; the Regional Development Commissions throughout the state; the Water Interests Advisory Committee; and other interested groups and persons. In such reviews and resultant changes, the positions of the individual and/or of their agencies may have been altered.

This paper was approved by the Minnesota Water Planning Board on ________ ______________.

Thomas Kalitowski, Chairman
Minnesota Water Planning Board

SUMMARY

I. Background and Overview

The Minnesota Water Planning Board has adopted the following goal as an objective for the Framework Water and Related Land Resources Plan:

> To outline alternatives to maximize the benefits of available water supplies at the present and in the future through (1) development of an assessment of the present and future water supplies and needs of the state; (2) the preparation of a system for equitably allocating the scarce resource in situations where quantities appear in danger of becoming inadequate to meet all state needs; (3) identification of means to efficiently utilize water resources; (4) cognizance of instream water uses and their relationships to water resources planning; (5) the development of management recommendations consistent with the options identified; (6) identification of mechanisms by which policies and decisions can be integrated so that agencies do not work at cross purposes; (7) the completion of special analysis and projects essential to the planning effort; and (8) the submission of recommendations and proposals to the Legislature.

The purpose of this report is to present a discussion on alternative approach to water allocation in fulfillment of part (2) of this goal.

II. Objectives

The basic objective of this report is to identify methods for obtaining the optimal distribution of water and approaches for implementing these methods. It assesses the efficiency and equity of current laws affecting water allocation in the state of Minnesota and other states and identifies options for allocating water at the sources and by intermediate water suppliers.

III. Summary and Conclusions

Problems of water allocation become relevant during periods of water shortage caused by drought and/or by increasing demands made upon the water resources of an area by a growing population and economy. The purpose of water allocation policy is to distribute the right to withdraw and consume water in such a way as to achieve the most efficient use of the water consistent with widely held social goals.

Water is allocated most efficiently when it is impossible to change the allocation without making at least one individual worse off. This concept of efficiency is not confined to variables traditionally considered to be economic ones. Rather, this concept requires that social costs and benefits beyond the private benefits of water users be taken into account in the allocation of water. For example, environmental and aesthetic considerations would also have to be taken into account. The particular efficient allocation to which a society will move should also depend upon the values widely held within the society. The term equity as used here refers to allocation of water in conformity with such values. Examples of values which are often brought up during discussions of resource allocation are the desire to provide for the minimum necessities of the poor and the desire to preserve the small family farm because of the values it is believed to promote.

Within the discipline of economic theory it has been shown that water can be most efficiently allocated if water is transferred, or reallocated, from uses which, in terms of the benefits received by water users and by society as a whole, are low valued relative to the costs of using it to uses where the water is high valued relative to the costs of using it. Laws, policies and institutions which do not inhibit or which promote such transfers are, from the standpoint of efficiency, more desirable than laws, policies and institutions which inhibit such transfers. The costs of water misallocation, in terms of foregone tangible and intangible benefits, and hence, the desirability of efficient transfers become more significant during water shortages — particularly during water shortages of long duration. With the exception of droughts in the thirties and in 1976, and of water-shortage problems in some western areas of the state, water-shortage problems have not been of great significance in Minnesota.

So far, current water law and policies of the Department of Natural Resources have worked reasonably well. However, there is reason to believe that in severe water-shortage conditions, particularly ones of long duration, some of these laws and policies could inhibit efficient and equitable water allocation. In particular,

1. The riparian doctrine, which is the basis of current Minnesota water law limits the use of water to riparian land. Thus, water allocation under the riparian system is primarily determined on the basis of location and not on its values and costs in alternative uses as would be required to attain the efficient allocation of water. Under current state law, transfers to nonriparians by water utilities and arrangements for some transfers on a case by case basis have been permissable, but wider use of such transfers may be necessary to secure efficient water allocation in water-shortage circumstances.

2. During a water shortage, the current Minnesota priority system as established in M. S. 105.41 could inhibit the efficient and equitable allocation of water. This is because the priority classifications have little relevance to the marginal values and costs of water in alternative uses and because they do not reflect the values of many segments of the public. It can be argued that under this priority system unjustifiable discrimination in favor of certain classes of users may take place. In addition, the current priority system is statewide in nature and does not take into account regional and local differences in the hydrological features and in the costs and benefits of water use.

The current Minnesota water allocation system does, however, have some advantages which should not be overlooked. Among these are the following:

1. It is politically acceptable.

2. Since domestic use has the highest priority under this system, basic necessity uses are for the most part protected _vis à vis_ most other uses.

3. The system is relatively inexpensive to administer and the administrative structure is currently in place.

4. Alternatives could be technically difficult to implement, expensive to administer. Legal and constitutional problems could be encountered and extensive statute changes required if the system were to be altered significantly.

In spite of this last point, certain suggestions are presented in this report for securing more efficient and equitable allocation of water during water shortages and for permitting more regional (this term does not necessarily refer to state Regional Development Commissions) flexibility in water allocation policy. In addition, certain more specific options for water allocation are presented which could be considered for implementation at specific hydrologically-defined areas. Such consideration would necessarily require more in-depth consideration of the options, particularly with regard to:

1. The expected benefits and costs of each option where applied,

2. How the program would be implemented and administered, and

3. The legal and constitutional issues involved.

In all of the options considered, it is assumed that the Department of Natural Resources would retain responsibility to:

1. assess the capability of the hydrological system to sustain withdrawals, and

2. control the total amount of water which is withdrawn and consumed from a hydrological system in order to protect the environment and the rights of all affected parties.

Within the bounds of these qualifications, the following recommendations are offered.

A. To effectively manage water resources in the state, especially during water shortages, accurate data concerning water withdrawals is necessary. Thus, withdrawal meters should be required of all permitted users except in cases where users can demonstrate that the use of such meters is technically infeasible or, in terms of cost, prohibitive. In such cases, alternative means of accurate withdrawal measurement should be required. To help secure compliance with this recommendation intake, meters could be required on all new permitted wells and water installations and the installment of such meters could be required on new wells and other water intake installations undergoing modification, unless the permittee could demonstrate that the use of such meters was technically infeasible.

B. The Water Planning Board recommends that the priority system of M.S. 105.41, subd. 1a be repealed. In its place, a system should be established which looks first to meet basic human needs and second to protection of the environment. Basic human needs and environmental protection will be determined based on local demographic, hydrologic, environmental, and inter-area dependencies. After basic needs are met, any allocation shall be based on economic, social, and hydrologic considerations relevant to the area involved. Local and/or regional water management plans should be developed--consistent with state plans--to guide such decisions.

C. To assist in meeting problems of uneven water distribution, it is recommended that the State of Minnesota adopt as its explicit policy the use of lease-easement arrangements subject to consideration of water availability and the exigencies of the particular situations involved.

In the longer term, further consideration should be given to (a) water sales by riparians to non-riparians and (b) mutual water companies. Specifically, these considerations should focus on the legal and constitutional issues involved and how such a program would be implemented and administered.

These options are discussed in more detail in Section V ("Allocation at the Source"). In considering these options, their legal and constitutional implications would have to be studied in depth.

D. In order to promote efficient allocation of water at specific water sources during water shortages, it is recommended that in its long-run planning efforts, the Water Planning Board give further consideration to (a) pro-rata rationing, (b) benchmark water-shortage pricing, and (c) trading in joint permit shares. In such consideration, the expected benefits and costs of each option, the administrative procedures by which each option could be implemented, and the legal constitutional issues involved would have to be studied in depth.

Pro-rata rationing involves apportioning available water among permitted users at a source according to their past withdrawals or the maximum allowable withdrawals under the terms of their permits. This approach would tend to result in inefficient water allocation, but it would be relatively easy to administer. Thus, it could be more appropriate for use during a severe temporary water shortage of short duration where the costs of misallocation would not have time to accumulate.

Benchmark water-shortage pricing involves the establishing of a per-unit water price for withdrawals from a water source when the level of the water (in a ground water source or lake) approaches a predetermined benchmark level or, in the case of a river or stream, the flow of the water approaches a benchmark flow. The benchmark flows would be determined on the basis of environmental and hydrological considerations. As the benchmark level or flow is approached, the price is raised to discourage water use. If levels or flows are well above the benchmark parameters, the per-unit price would be set at zero.

This approach would tend to produce efficient water allocation at the source because individual withdrawers would be forced to take into account the value of the resource in their withdrawal decisions.

The establishment of benchmark water-shortage pricing at a given water source would depend upon the ability of the water management authority to monitor hydrological conditions and adjust the price charged per unit of water accordingly. Thus, in many areas it may not be technically feasible to implement at this time. In addition, it would be more expensive to operate and administer than pro-rata rationing. It would, therefore, probably be most suitable for areas suffering from chronic water shortage problems where the costs of misallocation would accumulate over time.

One way to avoid the inefficient allocation which would take place under pro-rata rationing and to avoid the trail and error approach of benchmark water-shortage pricing would be to establish a system of trading in joint permit shares. This would involve the issuing of a joint permit to all current permit holders at a particular water source. The maximum current withdrawal allotment specified on each permit could be converted to shares in the maximum allotment attached to the joint permit. These shares would then be tradeable. In essence, a mutual water company would be established among all withdrawers on the source.

As with a mutual water company, an equilibrium share price would be established and water would be allocated more efficiently.

The costs of administering this arrangement would be assessed against the share of the joint permit holders. Thus, it would be necessary to secure a sufficient number of members to prevent the cost burden on any single share owner from being too high. This arrangement would, therefore, be most suitable for use at water sources supplying a large number of withdrawers where chronic or recurring water-shortage problems existed.

This arrangement is discussed further in Section V., D) of this report. Obviously the legal and constitutional implications of this option would have to be explored more deeply in its further consideration.

E. Zoning is neither an efficient nor equitable arrangement for allocating water; however, in the absence of needed technical information for other approaches to allocation it can be used to slow down the growth in demand for water in an area where water resources are known to be limited and thereby to protect local users from unacceptable water consumption cost increases and to protect environmental assets such as instream flows necessary for wildlife habitat.

F. Rules and guidelines for the settlement of well-interference disputes should be based on the principle that persons who withdraw water should bear all of the costs of their withdrawals including those costs which they impose on others. The operation of this principle should be made conditional on "reasonable effort to capture" by well owners alleging well interference; that is, that such well owners, if they show interference, could be compensated only over and above the costs of "reasonable effort to capture". Procedures for defining "reasonable effort to capture" under different hydrological circumstances could be established by the Department of Natural Resources.

Intermediate water suppliers are municipal water utilities and rural water systems, both of which are referred to in this report as <u>water utilities</u>. Water utilities withdraw water from a source in order to sell it to their customers. There are two reasons why the rate structures of water utilities should be of concern:

1. Water delivered by water utilities directly provides satisfaction to individuals through its fulfillment of their personal needs and wants. It indirectly provides satisfaction to individuals by permitting firms to provide goods and services, jobs and income. Thus, the way in which this water is allocated within the service area affects the satisfaction, directly and indirectly from its use.

2. The water utility acts as an agent for the individuals and firms in its service area when it competes for water with other users (e.g., with self-supplied industrial users, irrigators, persons using water for recreational purposes) at each of its sources. The rates charged by water utilities affect the total demand for water consumption by its customers. Thus, the total satisfaction of all users of water at or from each source depends on how water is allocated within the utility's service area.

The following recommendations are suggested for improving the efficiency and equity of water allocation by water utilities:

G. Local water utilities shall be encouraged to consider the adoption of rate structures based on marginal cost principles such as the three part rate structure discussed above, in order to bring about the more efficient allocation of water among their customers and to prevent excessive demand for water at the source and uneconomic capacity expansions. In cases where it appeared that the adoption of such a rate structure by a water utility would put undue cost burdens on low-income families, the water utility should consider adopting as part of its rate structure the payment of lump-sum subsidies to such families each billing period in the form of reductions in their fixed service charges. The losses in revenue resulting from such subsidies could be made up by higher service charges to other water users. Such families would pay normal per-unit water rates (based on marginal cost pricing). To encourage the consideration of such rate structures, the state shall fund a pilot project whereby such rate setting practices can be tested through actual application by a local water utility.

H. In considering the merits of rural water systems, attention should be given to their potential ability to bring about more efficient allocation of water. Rural water systems have the ability to transfer water from places where it is relatively plentiful and, therefore, less highly valued, relative to the costs of using it, to places where it is relatively scarce, and therefore, more highly valued relative to the costs of using it. They provide a means of establishing efficient allocation among their customers.

INTRODUCTION

The purpose of this report is to identify a set of options and make recommendations concerning policies which affect the allocation of water among withdrawal and nonwithdrawal uses. Some of these options may be currently implementable, but most of them will require some institutional and legal changes as well as the accumulation of more information concerning the hydrology of the state. Some of these policies may not be implementable until far into the future. However, as growth in the state takes place, greater and greater demands will be made upon available water resources in some areas and water shortages may become more frequent and more severe. Thus, the need for implementable water allocation policies is likely to become more acute as time passes.

This report is not confined to policies which could be implemented and administered on a state level. It would seem desirable given the area-specific nature of water allocation problems that many of the policies suggested here be implemented, or at least administered, on a regional level, perhaps with state financial or technical assistance. The question of who should implement or administer such policies falls within the purview of the Management Workgroup of the Minnesota Water Planning Board.

A. Why Allocation?

The term "allocation" with regard to any resource refers to the way in which that resource is "distributed" among uses. Depending upon the focus of a discussion, "allocation" may refer to distribution in a single time period or over several time periods.

Concern over the allocation of water arises in the context of water-shortage problems, well-interference problems, and the distribution of water by water utilities (including rural water systems).

1. Water "Shortages"

The concept of "water shortages" is both an economic one and a political one. It may be defined as follows:

> Water Shortage: A water shortage exists in an area when the consumptive and non-withdrawal demands for water relative to available supplies is such that the real costs of obtaining and/or using water become unacceptable to the public.

Water shortages are characterized by time and space dimensions. They may be restricted to a particular region or the state or they may occur in several regions simultaneously as did those occurring during the drought of 1976. They may be brought about by seasonal dry weather conditions or by occasional (or periodic) droughts. They may be of limited duration or they may last for several seasons. Or, they may become a chronic condition brought about by increasing demands upon the water resources of an area due to population growth and industrial (including agricultural) development. One effect of increasing demands over time is to make the consequences of droughts and seasonal dry periods more severe.

A more complete explanation of this definition and of the specific problems which can occur due to water shortages is available elsewhere (Fox, et. al., pp. 1-15). The main point is that as water availability relative to demand decreases (such as during a drought) or as the demand for water relative upply increases (such as due to economic growth in an area), the costs of using the water increases.

In general, water resources have been plentiful in Minnesota relative to the demands placed upon them; however, widespread problems of drought occurred in the thirties and in 1976, and chronic or recurring problems of water shortage exist in some western parts of the state, in many cases, because of the geographically uneven distribution of water sources.

The purpose of water-allocation policies in the context of water-shortage problems is to seek to provide answers to the following questions:

a. How should water be distributed during water shortages?

b. How should the costs of water shortages be distributed?

c. How should the benefits of water use be distributed?

d. How should the net benefits (benefits less costs) of water use be distributed?

2. Well-Interference Problems

The most common problems involving ground water are well-interference conflicts between irrigators and other users. Well-interference problems occur when the withdrawal of ground water by one user causes the level of the ground water in the vicinity of his well to fall interfering with the ability of one or more neighboring well owners to draw water. The frequency of these problems depends on the spacing of wells drawing from an aquifer and on the overall availability of ground water in the aquifer. An individual whose water supply is cut off by well interference may have to deepen his well, install a pump (in the case of an artesian well which stops flowing), and/or lengthen his drop pipe. In addition, he must use more energy in drawing the water.

Two questions concerning actual or potential well-interference problems must be addressed by allocation policy.

a. Under what circumstances should potential ground-water users be given the right to withdraw ground water?

b. Who should pay for the costs imposed by well interference?

3. Water Utilities

The phrase "water utility" refers to municipal waste utilities and rural water systems. In general, water is allocated by water utilities by some sort of pricing shceme. These rate structures affect both the allocation of water within the service area of the utility, and at the sources from which it withdraws water. There are, therefore, two reasons why these rate structures should be of concern if the maximum benefit from available water supplies in the state is desired.

a. Water delivered by water utilities directly provides satisfaction to individuals of households through its fullillment of their personal needs and wants. It directly provides satisfaction to individuals by permitting firms to provide goods and services, jobs and income. The way in which this water is allocated within the service area affects the satisfaction directly and indirectly derived from its use.

b. The water utility acts as an agent for individuals and firms of its service area when it competes for water with other users (e.g., self-supplied industrial users, irrigators, persons using water for recreational purposes) at each of its sources. The rates charged by water utilities affect the total demand for water consumption by its customers. Thus, the total satisfaction of all users of water at or from each source depends on how water is allocated within the utility's service area.

4. Allocation Over Consumption or Withdrawals

As with discussions of water demand, it is important to understand whether a discussion of water allocation is carried out in the context of water consumption or water withdrawals (See Fox, et. al., Section A, Introduction, for definitions of "withdrawal" and "consumption".). In discussions concerning water allocation on a river, it usually does not make sense to speak of allocating water over withdrawals. A large proportion of the water withdrawn from a flowing stream for various uses is returned to the stream and is available for subsequent reuse. Thus, during a specified time period it is possible for the total volume of water withdrawals to exceed the total amount of water available from a source. On the other hand, the sum of the volume of the water that is consumed during a specified time period in various withdrawal uses (including water which will be discharged during a subsequent time period) plus the water which must be retained in the river for non-withdrawal uses is limited by the volume of water (including discharges from previous time periods) which flows through the river. Thus, in such discus- "allocation" should refer to the distribution of water over the consumption of withdrawing uses and the amount left in the river for non-withdrawal uses.

In most situations, waste water discharges from uses which rely on ground water do not recharge the ground water source to any appreciable degree. Rather, the discharge runs off to surface water where some is reused and all eventually flows out of the region. If the use of water from this ground water source is the focus of the discussion, it would be appropriate to consider allocation over withdrawals; however, from the spective of this source, "withdrawal" and "consumption" are identical.

B. Levels of Allocation

There are three levels at which allocation can be carried out. These are:

1. Allocation Between Sources

On a large scale, these may involve "interbasin transfers" whereby water is carried over large distances between river or lake basins. Such large-scale transfers are usually impractical because of the costs and intergovernmental controversies involved. Thus, they will not be considered in this report.

On a smaller scale, allocation between sources may involve the transfer of water between nearby surface sources, between nearby ground water sources, or between surface and ground water sources. In some circumstances such transfers may be desirable, but only if it can be demonstrated that their benefits can justify their costs.

2. Allocation at the Source

This involves the distribution of water among those who withdraw and/or who use water from or in a single source or several hydrologically-related sources in close proximity. This would include the distribution of water among municipal water utilities, industrial withdrawers, agricultural withdrawers, private domestic withdrawers and water left in surface water sources to maintain levels or flows for non-withdrawal uses.

3. Allocation by Intermediate Suppliers

This concerns the distribution of water by municipal water utilities and rural water systems to their customers.

C. The Time Dimension of Allocation Policies

Time is an important factor in allocation policies in two senses. Some policies affect the allocation of water during current water shortages. Other policies affect allocation during future water shortages. Thus, time is important with regard to when the policies have their effect.

Time is also important in that certain policies can affect the allocation of water over time, i.e., between time periods. For example, peak load pricing of municipal water is an attempt to reallocate water from uses during peak water-use periods to off-peak periods.

D. Organization of Report

This report is organized into two main parts. Part 1. is concerned with the goals and theory of allocational policy and with using this theory to evaluate current state allocational policy and the policies of other states.

In Part 2. alternative approaches to allocation in Minnesota are discussed and recommendations made.

Part 1. Goals, Theory and Current Practice

I. The Goals of Allocation Policy

Specific goals of allocational policy having widespread approval would likely include the following:

1. Achieving the maximum rates of industrial output;

2. Achieving the maximum level of industrial earnings;

3. Achieving the maximum level satisfaction for residential users of water;

4. Achieving the maximum level of satisfaction for recreational users of water;

5. Achieving maximum satisfaction with the state of the environment;

6. Achieving the maximum level of employment; and

7. Achieving the most acceptable distribution of income.

A. Problems with Monitoring the Achievement of Specific Goals

There are three very substantial problems for policy planners seeking to achieve these goals: (1) it is extremely difficult if not impossible to measure the extent to which the goals have been reached, (2) not all of the goals are compatible with one another, and (3) it is difficult to determine whose satisfaction is to be achieved.

Out ability to estimate the economic impacts of specific allocation policies is at best highly limited. Such policies affect the costs to firms (including farms) and individuals of using water. The nature and direction of firm responses and the nature and direction of the ramifications of these firm responses upon the rest of the economy are discussed in Technical Paper Number 8: The Economic Impacts of Water Shortage and Water Allocation Policy. The quantitative magnitude of specific firm responses depend upon a variety of factors including technical features of the firm's plant and equipment, the market position of the firm, the state of the industry, where the firm obtains its raw materials, and the specific hydrological features of the site at which the plant is located. To quote Blair Bower, "Each situation involving plant site, production site, production process, product mix and the water environment tends to be unique." (Bower, 1966, p. 154.) Thus generalizations concerning the quantitative nature of firms' reactions are impossible. In addition, information concerning the quantitative nature of economic impacts through backward linkages is at this point in time dependent upon secondary or nonexistent data.

Variables corresponding to some of the goals are not even measureable. How, for example, does one measure the level of satisfaction with the state of the environment, the level of satisfaction of recreational water users, or the level of acceptability of the distribution of income? Indeed, whose satisfaction are we talking about: To whom must the distribution of income be acceptable?

These questions cannot be answered objectively. It may be possible to get some measure of residential water user satisfaction using statistically estimated demand curves; however, in the absence of any market for recreational pleasure or environmental satisfaction, there is no accurate way to measure satisfaction in these two areas. In particular, how does one add up the satisfaction of many individuals?

In some cases these goals (1 through 7) are compatible with one another. For example, the more flow there is in a river, the greater the capacity of that river to assimilate wastes. The lower the concentration of wastes, i.e., the less polluted the water, the more satisfying the environment and the greater the satisfaction obtained by recreational users of water. Thus, during a water shortage, approaching the fulfillments of goals 4 and 5 would require that instream flows be protected. However, maximizing output and earnings might require the discharge of more pollutants into the river of the consumption of more of its water. Thus, in some circumstances 1 and 2 will not be compatible with 4 and 5. Achieving maximum levels of earning and output may mean allocating water to industries with high capital (plant and equipment) to labor ratios away from industries with low capital-labor ratios. This may mean lower employment and a more unequal distribution of income. In other words, goals 1 and 2 may not always be compatible with goals 6 and 7.

B. Efficiency and Distributional Equity

Policy planners can seek to approach goals (1 through 7) indirectly by seeking the fulfillment of two criteria of a more general and abstract nature. The first criteria is that of efficiency. Suppose it were possible to reallocate water in such a way as to make some groups or individuals better off without making any other group or individual worse off. Clearly, society would be better off if such a reallocation were to take place provided that the cost of making the reallocation did not exceed the increase in benefits from having made it. Now, suppose the allocation of water were such that no such reallocation could take place. In other words, that it were impossible to make one group or individual better off without making another group or individual worse off. If such an allocation were to be achieved, absolute efficiency will have been reached. Thus, it is conceptually possible to approach efficiency by reallocating water in such a way as to improve the satisfaction of some groups without decreasing that of others until absolute efficiency is attained.

In practice, there are costs to making such reallocations in the form of the administrative, planning and material costs necessary to bring it about (the installation of meters, the laying of pipes to transfer water, etc.). The costs of such reallocations must be compared with the benefits of expected increases in efficiency from reallocations in deciding to pursue a particular policy.

In addition, it is not always possible to compensate those from whom water has been reallocated. Sometimes individuals or firms from whom water is reallocated are those who had been receiving unjustified subsidies for their water use in the form of real costs of water use imposed upon others. A reallocation of water may involve forcing such individuals or firms to internalize (assume) all of the costs of their water use. Clearly, this makes them worse off. A decision to reallocate water in this way also involves a distribution decision; that is, it is implicitly decided to make these parties worse off by removing their subsidies. The question of distributional equity is separate from that of efficiency and will be discussed below.

Note that moving towards more efficient allocation could involve the reallocation of water away from industrial uses toward keeping it instream for environmental and recreational purposes. Thus, the concept of efficiency does not necessarily favor activities commonly thought of as "economic" ones.

The concept of distributional equity concerns the distribution of the benefits of water use. An efficient allocation of water is not necessarily one that is equitable. The ultimate distribution of the benefits of water use among farms, factories, residential users, and that kept in streams and lakes for environmental and recreational pur poses may not be satisfactory to many segments of the public. And yet, the allocation may be efficient in that it would be impossible to redistribute the water without making at least someone worse off in terms of their satisfactions. In fact, there may be an infinite set of distributions which satisfy the criterion of efficiency. There is no objective way to determine the best allocation of water from the point of view of distributional equity. Planners and decision makers must use their judgement to determine that distribution of benefits which will be most widely acceptable.

The task for planners and the objective of this report is to develop allocation options which will promote the attainment of or at least wil not inhibit the attainment of more efficient and distributionally equitable allocations of water during water shortages. Because of the limitations on and the costs of obtaining information and because of the immeasurability of key variables, these options should feature the ability to allow the allocation of water to automatically and (as nearly as possible) optimally readjust to changes in the conditions of using water, to changes in economic conditions and to changes in people's preferences. Allocations reached should reflect values and goals widely acceptable among the various publics.

II. Some Results of Economic Theory for Efficient Water Allocation Policy and Limits on its Applicability

A. The Efficiency Guidelines

According to the economic literature concerned with the allocation of limited water supplies among competing uses (Hirshleiffer, et. al., 1960, pp. 33-73 and Bain, et. al., 1966, pp. 240-255), subject to the fulfillment of certain assumptions, two conditions are necessary and sufficient for water to be distributed efficiently in a given area. These will be referred to as the "efficiency guidelines." They are as follows:

1. The social marginal value in use of water for any two uses facing identical water cost conditions must be equal.

2. The social marginal value in use of water for any use

must equal the social marginal cost of the delivered water.

Demonstrations and proofs of the validity of these conditions are given elsewhere. Some definitions of importance are as follows:

1. The private marginal value in use of received water to an individual or institution is the maximum amount the individual or institution would be willing to pay for one more unit of water.

2. The social marginal value in use of water received by a given individual or institution is the private marginal value in use of water to the given individual or institution plus any value which others in society derive by virtue of the given institution or individual's receiving one more unit of water.

3. The private marginal cost of water received by an individual or an institution is the cost to that individual or institution for obtaining one more unit of water.

4. The social marginal cost of water received by a given individual or institution is the individual or instution's private marginal cost plus any cost imposed on others in society as a result of one more unit of water being received by the given individual or institution.

Included in the social marginal cost of water, but not necessarily in the private marginal cost of water to a given individual or institution, is the shadow price of water. This may be defined as the maximum price which water could command in a pure market situation among all alternative uses. It is, therefore, the value of water in the "best" alternative use. Since this value is lost to alternative uses, the shadow price is a form of opportunity cost.

From the standpoint of efficiency, water allocation can be improved if water is transferred or reallocated from uses in which the ratio of the social marginal value in use to the social marginal cost of the water is relatively low to uses in which this ratio is higher. Laws, policies and institutions which do not inhibit or which promote such transfers are more desirable than laws, policies and institutions which inhibit them. Such transfers will be referred to as efficient water transfers.

Efficient water transfers may be brought about through the sale of water or water rights among water users. A hypothetical demonstration of how this may occur is given by Hirschleifer, et. al. (p. 38):

"Suppose that my neighbor and I are both given rights (ration coupons, perhaps) to certain volumes of water, and we wish to consider whether it might be in our mutual interest to trade these water rights between us for other resources — we might as well say for dollars, which we can think of as a generalized claim on other resources like clam chowders, baby-sitting services, acres of land, or hachts. My neighbor might be a farmer and I an industrialist, or we might both be just retired homeowners; to make the quantities interesting, we will assume that both individuals are rather bid operators. Now suppose that the last acre-foot of my periodic entitlement is worth $10, at most, to me, but my neighbor would be willing to pay anything up to $50 for that right — a disparity of $40 between our marginal values in use. Evidently, if I transfer the right to him for any compensation between $10 and $50, we will both be better off in terms of our own preferences; in other words, the size of the pie measured in terms of the satisfactions yielded to both of us has increased. (Note, however, that the question of whether the compensation should be $11 or $49 is purely distributional.)

"But this is not yet the end. Having given up 1 acre-foot, I will not be inclined to give up another on such easy terms — water has become scarcer for me, so that an additional amount given up means foregoing a somewhat more urgent use. Conversely, my neighbor is no longer quite so anxious to buy as he was before, since his most urgent need for one more acre-foot has been satisfied, and an additional unit must be applied to less urgent uses. That is, for both of us marginal values in use decline with increases of consumption (or, equivalently, marginal value in use rises if consumption is cut back). Suppose he is now willing to pay back $45, while I am willing to sell for anything over $15. Evidently, we should trade again. Obviously, the stopping point is where the last (or marginal) unit of water is valued equally (in terms of the greatest amount of dollars we would be willing to pay) by the two of us, based on the use we can make of or the benefit we can derive from the last or marginal unit. At this point no more mutually advantageous trades are available — efficiency has been attained."

Individuals and institutions make individual decisions based on their private marginal values in use and private marginal costs of water. But from society's point of view, efficiency is obtained only when the theoretical conditions based on social marginal costs and values are fulfilled. Thus, there are divergencies between private decisions and public needs which must be bridged by public policy.

B. Externalities and Public Policy

The divergence between private and social benefits and costs (i.e., the differences between private and social marginal value in use and between private and social marginal costs) are a primary raison d'etre for the public sector's involvement in water management. In essence, it means that private decisions alone cannot necessarily be relied upon to approach efficiency in water allocation, mainly because private individuals and firms cannot and do not take into account all of the effects of their private decisions upon others.

Such effects are called externalities. They may be classified into two varieties: pecuniary externalities and nonpecuniary externalities. Pecuniary externalities occur when the decisions of private individuals affect others through market channels. Nonpecuniary externalities occur when these effects are through non-market channels. (Scitovsky, 1954.)

Types of pecuniary externalities which may have to be considered in attempting to arrive at more efficient allocations of water are as follows: Suppose that in the interest of obtaining a more optimal allocation of water a policy is implemented which has the effect of reallocating water from Industry A to Industry B. For example, such a reallocation could be effected in a particular area by limiting water use permits issued to new and expanding firms in Industry A, and by encouraging firms in Industry B to locate in the area. Such a policy would involve losses (smaller growth) for industries linked with Industry A through sales-purchase relationships and would involve gains for those linked with Industry B. The private marginal value in use of water to firms in each industry understates its social marginal value in use by failing to take into account these economic interdependencies. If the indirect gains associated with transferring water to Industry B were less than the indirect losses associated with a lesser allocation of water to Industry A, then there would be a net loss associated with the reallocation of water, even if the theoretical guidelines were fulfilled in a private sense (Hartman and Seastone, pp. 72-86).

Another type of pecuniary externality involves the per capita costs of government services (Hartman and Seastone, pp. 86-88). These can be positive or negative depending upon how labor migration caused by water reallocation affects the per capita costs of governmental services in the area affected by the water reallocation, and in other areas affected by the migration.

Pecuniary external benefits can be used as an argument for subsidizing firms in certain industries in their use of water. Unfortunately, such externalities are difficult to measure and to compare among uses. Thus, the burden of proof should fall upon those who request or advocate such subsidies.

The physical nature of water resources is such that almost all uses of water result in nonpecuniary externalities. For example, part of the costs of one individual's water withdrawals from an aquifer are borne by other persons who pump water from the same aquifer when the former's use results in a lowering of water levels, increased costs of pumping, and increased well-interference problems for the other users. Waste discharges from one use along a river affect the intake water and therefore the costs of other uses downstream. Withdrawals of water from a river for industrial use reduce the amount available for fish habitat and, thereby, may adversely affect the environment and recreation opportunities. These are examples of private costs differing from social costs because of the presence of nonpecuniary externalities. An example of private benefits understating social benefits would be a case where the entrapment of water behind a hydroelectric dam had positive benefits for the recreational use of water upstream.

In many cases, the nonpecuniary external effects of water use and water policy cannot be measured in dollars and cents. It is possible to estimate, in money terms, the private marginal value in use of water to a firm which contemplates locating upstream from a recreational, wildlife area. But how does one take into account the loss in the recreational value of the water due to pollution, and the impact on wildlife? This is a classic example of non-comparability and conflict of social goals: the maximization of recreational and ecological amenities not subject to such measurement. Such conflicts are subject only to legislative solution.

C. Limitations of the Efficiency Guidelines

The efficiency guidelines enumerated above cannot be directly applied towards the creation of water allocation policy. Their role is limited to that of a theoretical framework from which practical criteria for developing policy must evolve. Three groups of factors are responsible for this limited role. These factors have to do with:

a. Information limitations and uncertainty;

b. Second best effects; and

c. Fixed cost problems.

1. Data Limitations and Uncertainty

Unfortunately, any attempt to develop water allocation policies for the state will be hampered by insufficient information concerning such factors as:

a. The way water is used by a myriad of different industrial (including agricultural) processes, the rates at which water use varies with output, the use of other inputs and the potential for technical change affecting the use of water in these processes;

b. Hydrological conditions in thousands of specific locations where water is used; and

c. Random, cyclical and secular events affecting the economic and hydrological systems.

Thus, it is necessary to design allocation policies which will tend to promote efficient water allocation and which are amenable to adjustment by trial and error.

2. Second Best Problems

The nature of these problems is expressed by the following question: "If somewhere in the economy institutional arrangements are such that some of the conditions for achieving the efficient allocation of all resources cannot be met, can a second best situation be attained if all other efficiency conditions are met?". A similar question is: "Can efficiency be achieved on a piecemeal basis?". The answer to these questions according to the theory of the second best is "no".

This answer from theory would not seem to auger well for the usefulness of the efficiency guidelines since there can be no denying that in the "real world", efficiency conditions are very often not met and are constrained from doing so by powerful institutional forces. Monopolistic and monopsonistic practices in labor and product markets by large corporations and labor unions are common in the American economy and prevent the attainment of efficiency in resources and product markets.

Can it be argued, therefore, that seeking to fulfill the efficiency guidelines in water use will promote overall optimality? Perhaps not. On the other hand, perhaps they are useful in the achievement of more modest goals. Clearly, if no third parties are adversely affected, a transfer of water from low-valued uses to high-valued uses (relative to costs) improves the allocation of water, even it overall optimality is not achieved.

Within the context of the theory of the second best itself, it can be shown that if situations in which efficiency guidelines are violated are not closely related to situations in which improvement is sought, a piecemeal approach can work. For example, the utility of the guidelines in improving the allocation of water in the agricultural sector in order to maximize crop output given limited water supplies is not likely to be affected by oligopoly in the automobile industry.

The existence of the problem of the second best in principle, however, does make it necessary to study the context of specific water allocation problems or classes or problems in order to take into account relationships with factor and product markets in which there exist constraints against the achievement of efficient conditions. (Lipsey and Lancaster, pp. 11-32; and Henderson and Quandt, 1971, pp. 286-288.)

3. Fixed Cost Problems

In seeking to arrive at a more optimal distribution of water among competing uses, certain fixed costs may be incurred. Such costs are referred to as "fixed" because they do not vary with the amount of water supplied or used. Examples of these are the costs of installing meters to monitor water use, the costs of construction of capital facilities to pump, process or store water, and certain costs of managing water allocation policy. Cost of such investments do not vary with the quality of water used or stored.

To be worthwhile, the overall benefits achieved from a more optimal allocation of water must exceed the value of these fixed costs. In many small municipalities, for example, the cost of installing water meters might well exceed any gains from the use of per-unit rates to allocate water efficiently.

D. Practical Criteria for Efficient Allocational Policy

The basic message of the economic theory for allocational policy is that in many specific cases, an improvement in the efficiency with which water is allocated is possible if policy is designed to implement the efficiency guidelines subject to the qualifications just discussed. In practical terms, this means that water allocation policy should:

1. Seek to achieve or to remove obstacles to the achievement of economic efficiency by promoting or allowing appropriate water reallocations.

2. Be operable even in the absence of complete information.

3. Take into account external effects on parties not directly affected by water reallocations.

4. Have minimum fixed costs of implementation including management and investment costs.

5. Take into account market imperfections in economic sectors directly affected by water reallocations or in closely related sectors.

III. A Brief Overview of Laws and Statutes Affecting Water Allocation in Minnesota

The logical starting point for summarizing the body of water rights law in the State of Minnesota is the riparian doctrine. Historically, this doctrine is based upon the common law of England. Over the centuries as conflicts and cases in Britain arose, the English courts developed criteria to deal with them which became known as the common law. Minnesota, when it became a state, adopted this common law as a basis to be followed by its own courts, as did most all other states. As time passed, the common law was modified substantially both by the Judiciary and the Legislature in light of the specific needs and conditions of the state.

A. Case Law and the Riparian Doctrine

1. Surface Water Case Law

Riparian rights, as they were developed in England, are based on the ownership of land abutting on a body of water. There is no ownership in the corpus of the water but only a right to have it pass by your property, unhindered and undiminished in quantity or quality. Each landowner along the banks has an equal right to the water. Historically, under the common law only "natural" uses could be made by the riparian owner; this was limited to only essential domestic uses. Irrigation or any other consumptive use was considered "artificial" and was not allowed.

Under this doctrine, if a riparian owner sells a portion of his land that does not abut the body of water, riparian rights do not pass to the new owner. Also, if a riparian buys land adjoining his riparian land but not abutting the body of water, riparian rights do not apply to the new land. That is, riparian rights can be diminished and they cannot be expanded.

The historical common law riparian doctrine is very strict and over the years most riparian states, including Minnesota, have modified it into what is known as the American reasonable use doctrone of riparian rights. Under this doctrine, each proprietor has a privelege to make a beneficial use of the water for any purpose, provided that such use does not unreasonably interfere with the beneficial use of others. That is, the use must be reasonable and it must not unreasonably interfere with any other use. What is reasonable and unreasonable is to be decided on a case by case basis by considering the particular facts involved.

In Red River Roller Mills vs. Wright, 30 Minn. 249, 15 N.W. 167 (1883), the Minnesota Supreme Court stated.....

> "His (riparian owner) enjoyment must necessarily be according to his opportunities prior to those below him, and subsequent to those above him, and liable to be modified or abrogated by the reasonable use of the stream by others."

This is, the right of a riparian to use water is limited by the degree and the manner that other riparians use the water.

This is further complicated by the fact that riparian rights are not lost by nonuse. In Reeves vs. Backus-Brooks Co., 83 Minn. 339, 86 N.W. 337 (1901), the Minnesota court stated.....

> ". . .it matters not how much the owner of land upon a stream has actually used the water, or whether he has used it at all, his right to the use of it as a riparian owner remains unaffected during any period of time."

It is possible that if, at a certain point in time, a particular use of X amount of water by a riparian is deemed reasonable; at a later time, when more riparian's are exercising their rights, the use or the amount might be deemed unreasonable.

Due to Minnesota's relative abundance of water such situations have been rare to date.

In Mitchell vs. City of St. Paul, 225 Minn. 390, 31 N.W. 2d. 46 (1948), the court held that the use of water for a municipal water supply was a public right and was supreme over all other rights. That is, the use of water for the inhabita ts of a city is reasonable per se and has paramount priority over all other rights. It should be noted that this holding has been modified somewhat by recent Minnesota statutes, which will be discussed later. The preference for municipal or domestic use is very common across the country, even in nonriparian states.

2. Ground Water

Under the common law of England, a property holder owned everything above and below his land. There was absolute ownership of all that lay under the land, including water. Under this doctrine, a landowner had an absolute right to pump all the ground water he wished even if he lowered the water table and affected his neighbor's well. While many states still have this old English rule, Minnesota has modified it by applying the American reasonable use rule to it. That is, you can pump all the groundwater you wish for any reasonable beneficial use, provided you do not unreasonably interfere with anyone else's beneficial use. As with surface water, the decision as to what is reasonable an unreasonable is made upon the particular facts of each case.

B. Statutory Law

The State of Minnesota has required a permit to appropriate water since 1937. The present law is Minnesota Statute section 105.41, subd. 1, which states that a permit is required for anyone appropriating or using any surface or ground water in the state, and charges the Commissioner of Natural Resources with the responsibility for issuing the permits. Any domestic use serving less than 25 persons is exempt from this statute. Department of Natural Resources rules also exempt users who withdraw less than 10,000 gallons per day and less than 1,000,000 gallons per year. This further examption is permissible under M. S. 105.41, subd. 1b.

Section 105.44 sets furth the procedure that is followed after an application for a permit is received. Subdivision 1 requires maps, plans and specifications detailing the proposed appropriation, including environmental effects and possible alternatives.

The Commissioner may invoke a public hearing on an appropriation permit request but if such a hearing is demanded by affected parties, a hearing must be held.

Under section 105.45, the Commissioner is required to grant a permit if the applicant's plans are reasonable, practical and will adequately protect public safety and promote the public welfare. This section, in effect, makes the American reasonable use doctrine the criteria for the issuance of permits, with the Commissioner of Natural Resources deciding what is reasonable and unreasonable. The Commissioner also has the power to cancel or modify the terms of a permit under section 105.44, subd. 9.

> Subd. 9. Limitations on permits. Except as otherwise expressly provided by law, every permit issued by the commissioner of natural resources under the provisions of Minnesota Statutes 1949, Sections 105.37 to 105.55, or any amendment thereof, shall be subject to the following:
>
> (1) Cancellation by the commissioner at any time if deemed necessary by him for any cause for the protection of the public interests;
>
> (2) Such further conditions respecting the term of the permit or the cancellation thereof as the commissioner may prescribe and insert in the permit;
>
> (3) All applicable provisions of law existing at the time of the issuance of the permit or thereafter enacted by the legislature;

(4) Any applications granted under subdivision 8, or deemed granted under the provisions thereof, shall likewise be subject to the foregoing provisions of this subdivision, and shall be subject also to cancellation by the commissioner upon the recommendation of the supervisors of the soil and water conservation district wherein the land to be irrigated is located.

Anyone who feels he was wrongly denied a permit or who is adversely affected by the issuance of a permit may seek an administrative remedy through Minnesota Statutes Chapter 15. If that proves inadequate, he may then bring the case to the courts.

The practice of the Department of Natural Resources has been to issue permits based upon the reasonable use theory, subject to the statutes setting forth guidelines. It should be noted that the Department of Natural Resources is presently formulating a written set of rules and regulations that will govern water permits.

The pivot point of the statutes that concerns water permits is the priority scheme set forth in Minnesota Statutes 105.41, subd. 1a. The law sets up a five-tier priority system. First priority: domestic water supply, excluding industrial and commercial use of municipal water supply. Second priority: any consumptive use of less than 10,000 gallons per day. Third priority: agricultural irrigation and agricultural processing. Fourth priority: power production. Fifth priority: other uses.

The way the system works, if a lower priority user interferes with a higher priority user, for example, if an irrigator interferes with a domestic well, the domestic user has legal priority over the irrigator. In the actual chain of events, the Department of Natural Resources, Division of Waters attempts to reconcile the situation either by adjusting the irrigator's permit or working out an agreement where the irrigator helps to improve the domestic well. If this is unacceptable, then there are administrative remedies and then the courts.

Section 105.415 provides a special procedure for permits requesting ground water use for irrigation. Class A applications are for areas of the state that have adequate ground water data. Class B applications are for areas that do not have sufficient hydrological data for determining the merits of each application. Class B applications require aquifer information and, in some cases, a pumping test before a permit is issued.

Section 105.416, subd. 3, states that a permit will not be issued unless the water supply is available for the proposed use without reducing water levels beyond the reach of vicinity wells constructed in accordance with the water well construction code.

Appropriation from surface waters is covered by section 105.417. It requires that no consumptive uses of surface water be allowed during low flow periods. Subd. 3 limits collective withdrawals to one-half acre-foot of water per acre of waterbasin, for each waterbasin in the state. This section also provides for a "protection elevation" for each waterbasin, below which no appropriation will be allowed.

This protection elevation is for both ecological reasons and to maintain the levels for other uses. Appropriations from designated trout streams are limited to temporary permits. Lastly, this section requires each application for surface water to provide a contingency plan that will be followed if further appropriation is restricted.

Minnesota Statutes section 105.418 provides that during a critical water deficiency as declared by the Governor, public water supply authorities must restrict lawn sprinkling, car washing, golf course and park irrigation and other non-essential uses.

The iron and copper-nickel mining industry receives special consideration in section 105.64. They may be granted permits for the drainage, diversion control of, and use of, any water for the mining of ore.

While the Department of Natural Resources has the main responsibility for water within the state, there are other agencies that are concerned with it.

The Water Resources Board was created to provide a forum for conflicts concerning water rights. In sections 105.71 to 105.79, the procedure by which the Board hears cases is set forth. The Board has the power to hear questions of water policy in the areas of water conservation, water pollution, preservation of wildlife, drainage, soil conservation, public recreation, forest management and municipal planning.

The Water Resources Board is also responsible for the establishment of watershed districts. These are local districts formed by Minnesota Statutes, chapter 112. The purposes for which a watershed district can be established include flood control, improvement of stream channels, water supply for irrigation, regulating stream flow and providing water supplies (section 112.36).

Under section 112.71, the district has a property right in any water that the district's works or systems make available. The district then may lease or assign such property rights for compensation.

Soil and water conservation districts may be formed under Minnesota Statute chapter 40. The purposes of such districts include preventing erosion, sedimentation and siltation, controlling floods, preventing impairment of dams and reservoirs, assist in maintaining the navigability of rivers and harbors and to protect wildlife (section 40.02). A soil and water conservation district may own and operate structural measures and other works of improvement to further such purposes. This implies that, subject to necessary approvals and permits by the commissioner, such districts would have the right to control the levels and use of waters within such improvements.

C. A Critique of Water Allocation Under Minnesota Water Law

1. Problems with the Riparian Doctrine

By itself, the riparian doctrine promotes neither the efficient nor the equitable allocation of water. Under this doctrine, the allocation of water is to a large extent determined by the location of individual water users, irrespective of the value and costs in use of the water to each of them. There are likely to be many situations where water transfers could take place between riparian and nonriparians so that parties to each transfer were better off. The efficient allocation of water cannot be achieved under a system of water law which inhibits such transfers. Under current state law, transfers to nonriparians by water utilities and arrangements for some transfers on a case by case basis have been permissible, but wider use of such transfers may be necessary to secure efficient water allocation in areas where water is unevenly distributed.

2. Problems with the Current Priority System During Water Shortages

Although the current priority system has in general been satisfactory, particularly with regard to the protection of domestic water supply, during a prolonged and relatively severe water shortage in a given area, it could inhibit the efficient and equitable allocation of water.

As stated in Section II. of this report, the efficient allocation of water depends on the marginal value of water in different uses and in the marginal costs of supplying water to these uses. The relative marginal values and costs of alternative uses have little to do with the classification of uses in the current priority system. While, admittedly, the marginal value of water in certain domestic uses is likely to be high, not all domestic uses are more vital than uses in lower priority classifications. In general, it can be stated that, from an economic point of view, not all uses of water in higher priority classes are more beneficial than uses in lower classes.

In addition, this priority system would not necessarily bring about equitable allocation during a water shortage. Again, this is because specific uses in higher priority classes may be less preferred to uses in lower priority classes according to the values of many members of the public and because unjustifiable discrimination in favor of certain classes of users may take place.

Finally, this priority system is essentially a statewide preference system which fails to recognize regional and local differences in the economic and technical conditions of water use, in local hydrological conditions and in citizen preferences.

IV. A Brief Overview of Laws and Statutes Affecting Allocation in Selected Other States

A. The Prior Appropriation Doctrine

There are essentially two doctrines of water law followed in the United States, the riparian doctrine and the prior appropriation doctrine. The riparian doctrine is based upon the common law of England

and is generally followed in the humid climate of the Eastern states. The prior appropriation doctrine is a uniquely regional product, developed in consideration of the relative scarcity of water in the Western states.

The essential elements of the riparian doctrine were discussed in the section on Minnesota water laws. It is unnecessary to repeat them here.

The historical roots of the prior appropriation doctrine go back to the California gold rush. The miners did not own the land they worked. They were trespassers or squatters on public property. Nevertheless, they needed water to wash the gold out of the hills, so they took it. As time passed, this ripened into a legal right to use the water, and was recognized by state law.

The basic theory of prior appropriation is first in time, first in right. That is, the first person to use the water of a particular stream has the right to any quantity of water he wishes, up to the full amount. The second in time can use only the amount not used by the first. The third can use any amount not used by the first and second, and so on. In times of shortage, junior appropriators were simply out of luck. The first appropriators took their full quantity of water even if that left none for the others.

Obviously, such a system is not likely to be equitable or efficient unless the sale or water rights is permitted. In theory, under the appropriative doctrine, such rights are freely alienable; that is, they can be bought and sold. However, in practice legal qualifications on such sales tend to inhibit them. (Gaffney, pp. 221 and 222.)

Appropriative rights can be lost through non-use. The water must be put to beneficial use and continue in such a use for the appropriator to retain his right. This means that it pays to use water whether one needs it or not as long as this use gives the appearance of being beneficial. This is hardly conducive to water conservation or efficient and equitable allocation. (Gaffney, p. 210.)

B. Water Rights Laws in Four Representative States

1. Ohio

The state of Ohio strictly adheres to the doctrine of riparian rights. Anyone wishing to use water must adhere to the doctrine of riparian rights and the reasonable use rule. There must be ownership of the abutting land and the uses that the water is put to must be reasonable and must not unreasonably interfere with anyone else's use. Every riparian owner makes his own decision as to the manner and the amount of water he will use. The riparian owner's decision is questioned only if another riparian brings a lawsuit claiming that his own use of the water is being infringed upon. Only then does the reasonable use rule of riparian rights come into play to decide who is entitled to how much water.

In Ohio, a water use permit is only required to withdraw water from a state-owned canal, lake or reservoir. This is a narrow proprietory purpose rather than an attempt to regulate the state's water resources. Ohio courts have upheld the common law preference for domestic water use; there are no other priorities followed.

In the area of groundwater, Ohio adheres to the English absolute ownership rule. That is, ground water is part of the land and the owner may withdraw as much as he pleases, provided only that there is no malicious intent to deprive someone else of water. While no permits are required and anyone can drill a well, the law requires that the drilling records of all wells be submitted to the Ohio Department of Natural Resources.

The Ohio water rights laws exemplify a system of minimum regulation. The ample rainfall and water resources of the Eastern states have minimized problems with such systems.

2. Illinois

The state of Illinois has a permit system, but it is severely limited in its scope. The permit law (Illinois Statute 19, section 65) is only applicable to "public waters". Public waters are by definition those bodies of water that are commercially navigable. The statute goes on to say that permits are needed for withdrawals of water for industrial, manufacturing and public utility uses. The criteria used to determine whether a permit should be issued is whether the withdrawal will interfere with navigation or any of the other public rights to use the waters. Permits are valid for a set number of years, up to a maximum of 40. Permits can be renewed. An interesting feature of this statute is that it allows permits to be issued to nonriparians.

All other uses and bodies of water not covered in the statute are governed by the reasonable use rule of the riparian doctrine.

While the Illinois statute is far from comprehensive and it was originally enacted only to protect navigation, in practice it provides some measure of regulation to most large water users in the state.

In the area of groundwater, Illinois adheres to the English absolute ownership rule. Nevertheless if you wish to drill a well you must file a notification of interest with the Illinois Department of Mines and Minerals, and if it will go below the glacial drift, a permit must be issued. Since permits are given as a matter of cource, this is not a regulatory statute. Its purpose is to gather data.

The Illinois system is typical of many eastern states. Most have some form of a permit system but with extensive exceptions so that a significant portion of the state's water use is outside of regulation.

3. Colorado

The state of Colorado is a "pure" prior appropriation state. The riparian rights doctrine was never adopted by the state. All water rights in Colorado are based upon prior appropriation. The Colorado Constitution in Article 16, Section 6, provides "the right to divert unappropriated waters of any natural stream for beneficial uses shall never be denied".

There is no permit system for surface water in Colorado. A person desiring water makes his own judgement as to the amount of unappropriated water in a stream and bases his appropriations on that. The state has set up a "water judiciary" within the court system. If there is any water dispute or if an appropriator wants to document his water rights, he may seek an adjudication. All appropriators on a particular stream may be brought in and a listing of priorities made. The water judge decides in what order the appropriators put the water to beneficial use and the amount each is entitled to.

In the area of ground water, a recent statute requires permits for withdrawal in those areas of the state that have experienced ground water problems.

About half of the Western states have a pure prior appropriation system similar to Colorado. The other half recognizes both prior appropriation and riparian rights.

4. California

California is a good example of a state who's water law is a mixture of appropriative and riparian rights. Under California law nonriparians who wish to appropriate water must obtain a permit as well as an easement to obtain water from riparian-owned lands. The California Water Resources Control Board makes a determination of the availability of water in the particular stream and decides whether to issue a permit based upon the public interest, which includes environmental concern and other beneficial uses of the water. The permittee must diligently put the water to beneficial use or lose the right.

Riparians do not need a permit to withdraw water, but they must put the water to reasonable beneficial use. In California riparian rights are not lost by non-use. Thus, future riparian uses must be considered. A use that is presently reasonable may be unreasonable in the future when more riparians are exercising their rights.

Conflicts between riparians are resolved by determining the reasonable beneficial use of a particular body of water. A significant limitation of the riparian right in California is that a riparian right may be inferior to an appropriative right. It depends on temporal priority, that is, who's rights were vested first. So if an appropriator began using water in 1880 from a particular stream, his rights would be inferior to those riparians who took title to their land from the federal government before 1880. Further, the appropriator's rights would be superior to those riparians who first took title after 1880. In this particular example, both pre-1880 and post-1880 riparians would have equal standing. The relative dates are only important between an appropriator and a riparian.

Ground water law in California is based upon the American reasonable use doctrine, that is, any reasonable beneficial use may be made of the water. California case law goes beyond that by applying the correlative rights rule. That is, disputes between overlying landowners concerning the use of ground water to which they have equal rights but of which there is insufficient supply for their total withdrawal demands are to be settled by allowing each to withdraw a fair and just proportion of the total amount withdrawn. Each overlying landowner is allowed to pump a "reasonable" share, usually based on the amount of overlying land he owns.

In the situation of ground water appropriations, that is where water is pumped from one basin to non-overlying lands, the doctrine of mutual prescription applies. If the basin is being pumped at the safe yield and then in one year there is an overdraft, the overlying landowners can bring an action to halt the appropriators from pumping in the reverse order from that in which the appropriators began withdrawing. However, if there is a continuous overdraft and the overlying landowners allow the appropriators to keep pumping for five years, then the appropriators have a vested right in a share of the ground water in any future adjudication, based on the amount each has pumped during those five years.

C. A Model (?) Water Code

In a Model Water Code by F. E. Maloney, R. C. Ausness and J. S. Morris (University of Florida Press, 1972), a comprehensive set of water laws is set forth. The authors formulated this code to take advantage of the best features of both the riparian and prior appropriation doctrines. The central point of the code requires a permit for all water use, surface and ground; exempting only individual domestic use. Permits are limited to 50 years for a municipality and 20 years for all other uses. Permits may be renewed. The criteria for the issuing of permits is whether the water will be put to a "reasonable and beneficial use." That being defined as "use of water is such quantity as is necessary for economic and efficient utilization for a purpose and in a manner which is both reasonable and consistent with the public interest". This combines the reasonable use rule with the prior appropriation beneficial use doctrine.

The model code has no preference system and in the case of two competing applications for a permit, the permit is given to the use that best serves the public interest. In the code, water rights could be lost through two years of non-use. In times of water shortages, the code provides for restrictive water use.

The main point of the Model Water Code is that it brings virtually all water use under state regulation. The present Minnesota code is similarly comprehensive, as it covers almost all water use in the state.

The Iowa Water Code (Chapter 455A) enacted in 1957 is similar to the model water code. Permits are required and the water must be put to "beneficial" use. Permits are renewable ten-year periods and water rights may be lost by three years of non-use. The Iowa Natural Resources Council has the right to establish minimum flows for all waterways and has the power to reduce water use during water shortages to protect the public interest. The Iowa code is not completely comprehensive as it does not cover certain substantial water uses that were in existence prior to 1957.

D. Conclusions

The prior appropriation doctrine, at least as it has been practiced in most western states, offers no improvement over the riparian system in Minnesota. Water is allocated on a first in time, first in right basis without any relationship to efficiency or equity. Water rights transfers, while theoretically possible under the system, are in fact, inhibited by mazes of legality.

The system of water allocation in the two riparian states considered, Ohio and Illinois, is probably inferior to the system as practiced in Minnesota. In both states, regulation of water withdrawals is minimal. In Ohio a water use permit is only required to withdraw water from a state-owned canal, lake or reservoir. In Illinois there is some regulation of withdrawals by large manufacturing plants and power utilities from commercially navigable bodies of water. In both states, the English absolute ownership rule applies to ground water withdrawals. Thus, individuals suffering well-interference problems must prove malicious intent in the courts. At least, under Minnesota law there is some protection for stream flows, lake levels and domestic use, and in water disputes, indirect costs of water use can be taken into account without having to prove malicious intent.

Water law in Colorado is based solely on the prior appropriation doctrine. Thus, the aforementioned criticisms of this doctrine apply to water allocation in this state. One feature of interest of the Colorado water allocation system is the "water judiciary" set up within the court system. Because of the technical nature of water disputes, a branch of the judicial system devoted solely to water problems seems a good idea. Judges within such a system would be well-informed on water-related issues because of their training and experience, and therefore, would be in a better position to understand the issues involved in each case and to make better decisions.

In California, environmental concerns and the reasonable beneficial use of concerned parties are taken into account in the granting of permits to non-riparians (who are able to obtain water from public lands or from riparian lands by means of easements) and in disputes among riparians. Thus, there is some attempt to achieve rational water allocation. Nevertheless, disputes among appropriative withdrawers and between appropriative withdrawers and riparian withdrawers are settled according to the first in time, first in right principle. disputes among ground water withdrawers are settled by proportional rationing often based upon the proportion of land held by each over the aquifer. Thus, for the most part allocation is based on historical factors and not on either efficiency or equity.

The model water code discussed in the previous subsection attempts to arrive at efficient water allocation by requiring that permits be issued for the economic and efficient use of water "consistent with the public interest", and by granting permits for that use which "best serves the public interest" when there is competition for the granting of a permit to water from a particular water source. Thus, the permitting authority as presumed to be capable of judging among the relative merits of proposed uses of water. The ability to make such decisions in Minnesota and, thereby, arrive at equitable and efficient water allocation, is limited by the lack of the necessary hydrological and economic information. Because, under this code, water rights can be lost after two years of non-use, an incentive is provided for the unnecessary use of water.

It would appear from the foregoing that in the allocation of water Minnesota could derive little benefit by adopting features of water law practiced in the states considered. Of greatest interest is the water judiciary which operates in Colorado. Such a system might be appropriate in Minnesota for dealing with water disputes which arise because of the inability of any water allocation plan or system to deal with all possible contingencies. The "model" water code of Subsection C leaves too much to be decided by the piecemeal approach of litigation and relies too much on the decisions of permit grantors.

Part II. Alternative Approaches to Allocation in Minnesota

V. Allocation at The Source

The purpose of this section is to present options for improving the efficiency with which water is allocated among those who withdraw water directly from a surface water or ground water source, and those who use water for non-withdrawal purposes. Thus, it is concerned with the allocation of water among self-supplied domestic users, self-supplied industrial users, intermediate water suppliers such as municipal water utilities and rural water systems, persons who engage in water-related recreation and environmental requirements for ground and surface water levels and flows.

This section is designed to provide a first consideration of the available options. Further research would be required before any of these could be finally accepted or rejected for use anywhere in the state. In particular, more detailed consideration would have to be given to administrative and other costs and to the expected benefits of some of the alternatives. In addition, possible legal and constitutional implications of the options would have to be explored.

All of the options presented for allocating water from a given source would require that the DNR first determine the maximum amount of water which could be withdrawn or consumed from the source and/or the magnitude of any other relevant hydrological parameters and that all arrangements for the allocation of the water be contigent upon the DNR's perogative to limit the total amount of water withdrawn from any public source.

A. The Current System in Minnesota

Certainly a viable option to consider is the current system of allocating water in the State of Minnesota discussed above in Section III. This system includes the riparian doctrine of common law, Minnesota Statute law including the water priority and permitting system, and DNR policy to implement the law.

1. Disadvantages of the Current System

In Section III, this system was criticized on the grounds that, particularly during severe water shortages, it could inhibit the efficient and equitable allocation of water. More specifically:

a. Water allocation under the riparian system is primarily determined on the basis of location and not on its value and cost in alternative uses as would be the case under an efficient allocation system. (See Section II for an explanation of the principles of efficient allocation).

Under current state law, transfers to non-riparians by water utilities and arrangements for some transfers on a case by case basis have been permissible, but wider use of such transfers may be necessary to secure efficient water allocation in areas suffering from water-shortage problems and where water is unevenly distributed.

b. The priority system is critisized (Section III. C, 2) on the grounds that during a water shortage it could inhibit the efficient and equitable allocation of water. This is because the priority classifications have little relevance to the marginal values and costs of water in alternative uses, because they may not reflect the values of many segments of the public, and because unjustifiable discrimination in favor of certain classes of users may take place. In addition, the current priority system is state-wide in nature and does not take account of regional and local differences in hydrological features and in the costs and benefits of water use.

2. Advantages of the Current System

The current water allocation system does, however, have some advantages. Among these are the following:

a. It is obviously politically acceptable.

b. Since domestic use has the highest priority under this system, basic necessity uses are for the most part protected vis à vis most other uses.

c. This system is relatively inexpensive to administer and an administrative structure is currently in place.

B. Allocation Among Riparians and Other Withdrawers During Water Shortages

The purpose of this section is to discuss the allocation of water during water shortages among riparians and other withdrawers. The "other withdrawers" are those who withdraw water from the source but do not use the water on riparian lands. This would include water utilities and rural water systems and could potentially include other nonriparian users who would withdraw water under the options suggested in subsections which follow.

It should be pointed out at the outset that the policies discussed here are not meant to be state-wide policies but could be applied at specific water sources where water-shortage problems occurred.

1. Pro-rata Rationing During a Water Shortage

This approach to water shortage could be applied during a temporary water shortage to protect the level of the water in a lake or aquifer, or the flow of water in a stream. It would be applied at specific locations where water shortages occur. The estimated available water supply would be apportioned among users according to the maximum withdrawal quantities specified on their permits, or according to their actual withdrawals averaged over some period of time. Thus, under this system, the allocation of water is determined by past use, not on the value of water in alternative uses and is, therefore, not likely to be efficient. If the duration of the water shortage were relatively short, the costs of this misallocation, in the form of foregone benefits, would probably be low. On the other hand, the costs of misallocation could be substantial if the water shortage were a chronic one of long duration.

In the absence of an effective way to monitor water use (for example with spot checks on meters), the enforcement of this policy would be forced to rely on moral suasion and education. Nevertheless, the policy would be easy to implement, since it would primarily entail informing water users to cut their water use by a fixed percentage or informing them that the maximum allowable withdrawals under the terms of their permits had been revised downward by a fixed percentage. Thus, this approach might be most useful in a temporary water shortage caused by a drought which was expected to be of relatively short duration.

2. Benchmark Water-Shortage Pricing

This option could be used at a specific water source where there is a water shortage. At present, widespread use of this option would be limited because, as discussed below, its operation would depend on the ability of a water management authority to monitor hydrological conditions and adjust the price charged per unit of water accordingly. Thus, it would probably be necessary at first to try out the policy at a particular water sources on an experimental basis.

According to economic theory, one way to allocate water at a source in such a way as to approach fulfilling the efficiency guidelines of Section II is to charge each user a per-unit consumption charge equal to the shadow price of the water. (See II. A for a definition of this term). Since each increment of water consumed by each user is less highly valued than the preceeding one, eventually users will on the average use just that quantity of water at which the marginal value in use of the water consumed equals the price charged for the water. Under this scheme, a single price would be charged for the water, thus efficiency guideline 1 would be fulfilled. If we assume that the private marginal value in use for each user is equal to the social marginal value in use, guideline 2 will also be fulfilled.

There is, however, a major problem with this approach. How is the shadow price of water to be measured? To estimate this accurately, detailed knowledge concerning the hydrological environment and the economic, social, and other benefits and costs of the water would be required. Usually much of this information is not available.

An alternative to attempting to estimating the shadow price of water at a source is to determine the price of water consumption by trial and error using objective hydrological indicators to judge the success of the policy.

Let us consider how this approach might be applied to allocating water from an aquifer or from a river.

a. Surface Water

A price could be established for river water consumed if during a water shortage the rate of flow of the river water fell to within some specified percentage points of the average flow in the river. For example, if a 10% of average minimum flow standard were adopted (See Gibson) then a price could be levied when the actual flow fell below 15% of average. The price could be adjusted until the 15% level were achieved. If at zero price the level of flow were above 15% of average, then zero is the proper price. If the flow is so low that the natural rate of the flow of the river (assuming no consumption) is 10% of the average flow or less, then the price of the water should be prohibitive in order to discourage any consumption. A similar program could be applied to lakes with lake levels being monitored.

Under this program, consumption of water for human basic necessities could be exempted or directly subsidized.

One problem with this approach is that it would be enforceable only on users with permits and meters and would require at least spot checks by personnel of the water-allocation authority. Thus, an unfair share of the cost of the program would fall upon metered customers. One way of ameliorating this problem would be to require more widespread metering or, where metering is infeasible, other approaches to the accurate measurement of water use.

b. Ground Water

A similar approach might be used in the future to allocate ground water. For a particular aquifer, a benchmark ground water level, for example the safe yield level, could be specified.

When the ground water level fell below the specified level, a water charge could be instituted and adjusted until the level were reestablished at the benchmark level, or until ground water use was halted to prevent excessive mining of the aquifer.

The Minnesota Department of Natural Resources is now in the process of expanding its network of observation wells to monitor the groundwater systems of the state. Such a network, along with the more widespread metering of ground water use would be necessary to implement such a program on a wide scale.

At the present time, only the roughest outline of this approach can be discussed. More detailed hydrological study would be required to establish procedures for determining benchmark water levels and appropriate means of monitoring them.

This approach would be more expensive to administer than pro-rata rationing because it would require the setting up, maintenance, and monitoring of hydrological monitoring equipment and because it would require personnel to establish and administer the prices charged. Thus, the costs of such a program might be justified only in areas where water shortages were chronic and where, in the absence of the policy, large costs of water misallocation would accumulate over time.

It is likely that any scheme for allocating water by means of pricing would run into stiff opposition. On the surface, it might appear heartless to increase the price of water during a time when firms (including farms) are suffering economic hardships due to a drought. The fallacy of this sort of thinking is that it assumes that water is free and that it is the allocating authority which is imposing a cost. In fact, during a water shortage, in the absence of any allocation policy, these costs exist in the form of opportunity costs and externalities imposed by users on each other. The purpose of a pricing policy would be to spread these costs out more evenly and efficiently by forcing users to take into account the implicit costs of their water use (see Section II. B above).

A significant obstacle to the achievement of overall efficiency in the allocation of water is a lack of information concerning the interrelationships among ground water and surface water sources in the state. Suppose, for example, that part of the water in a surface source recharges the level of water in a nearby aquifer. Then water consumption from the surface source may reduce the rate of recharge to the aquifer and affect ground water users. Thus, part of the shadow price of water consumed from the surface source is due to the effect of that consumption on the ground water users. To approach efficiency in the allocation of water from the perspective of both the aquifer and the surface water source, the impact of surface water consumption on the ground water source would have to be monitored as well as the level of water in the surface water source for pricing policy or for determining the amount of water to be pro-rated among permit holders.

Similarly, the impact of consumption of water from ground water sources on surface water sources would need to be monitored to approach optimality in the allocation of water from both types of sources.

Unfortunately, in order to monitor all such intersource impacts, much more hydrological information would be required than is presently available. Thus, allocation efforts will have to be practiced on the basis of currently available information concerning these interelationships. Modifications in policy will be required if it becomes apparent that water use from one source is adversely affecting water use from another.

3. Trading in Joint Permit Shares

One way to avoid the inefficient allocation which would take place under pro-rata rationing and the trial and error approach of benchmark water-shortages pricing would be to establish a system of trading in joint permit shares. This would involve the issuing of a joint permit to all current permit holders at a particular water source.

The maximum current withdrawal allotment specified on each permit could be converted to shares in the maximum withdrawal permission attached to the joint permit. These shares would then be tradeable. In essence, a mutual water company (see Section V. C. 3, below) is established among all withdrawers from the source.

The shares would be traded on the market so that a competitive price would be established for them. During a water shortage, the value of the water in different uses would be relatively high due to water's relative scarcity (in relation to the demands for it). The competitive price per share would, therefore, be relatively high. Thus, share holders would seek to limit their shares to cover just the amount of water they could use and to sell the rest. In other words, they would be induced to conserve water. Water would be allocated to those uses which were at least as highly valued as the price of the water. Thus, an efficient allocation among the joint permit holders would be established.

Such an arrangement would also promote efficient allocation because it would be a means of securing efficient transfers of water to nonriparian land owners.

To maintain the value of their land, sellers of property would sell permit shares along with the property. Thus, potential new users of water would have to take into account the cost of the water in making their location decisions.

The cost of administering this arrangement would be assessed against the shares of the joint permit holders. Thus, it would be necessary to secure a sufficient number of members to prevent the cost burden on any single share owner from being too high. This arrangement would, therefore, be most suitable for use at water sources supplying a large number of withdrawers where chronic or recurring water-shortage problems existed.

Obviously the legal implications of this arrangement would have to be considered. Under this arrangement, nonriparians could obtain shares in the permit, unless specifically prohibited from doing so. Thus, constitutional issues could be raised. In addition, the DNR would not have control over the specific quantities of water going to each withdrawer. Assuming, however, that the arrangement would lead to the more efficient allocation of water, it can be argued that water is used more reasonably and beneficially when it is efficiently allocated than when it is not.

C. Transfers of Water from Riparians to Nonriparians

The policies presented here would tend to correct for a basic defect of the riparian system whereby efficient water transfers are inhibited.

A major problem with any kind of water transfer between two parties concerns the impact on others not involved in the sale. Third parties can be affected in either positive or negative ways. For example, a transfer of ground water from A to C can cause well-interference problems for B if A allows a new well to be drilled on his land so that the transfer can be carried out.

Thus, under any system of water transfers, avenues must be available for affected third parties to obtain compensation for any damages they sustain due to others' water transfers. Disputes concerning alleged damages could be mediated or arbitrated by the allocating authority with ultimate access to the courts for aggrieved parties.

1. Lease, Easement Arrangements

Under this approach, a nonriparian obtains a lease from a riparian neighbor to a small amount of riparian land on which he sinks a well or installs surface water intake equipment, depending upon the type of water source. In addition, he obtains an easement from the riparian landowner to run a line to his own property. The lessee then acquires a permit to withdraw water for his purposes.

Under this arrangement, the tenant water withdrawer could potentially be in competition with the riparian landowner for water during a water shortage. Thus, it is in the interest of the landowner to charge a high enough rent to offset the expected costs of such a risk. On the other hand, the rent cannot be so high that it causes the total costs of the arrangement to exceed its benefits to the tenant.

Because of the lease and easement arrangement, the investment on the part of the tenant in water withdrawal and transmission equipment will be protected, at least until the lease expires. Unless, of course, the DNR drastically changes the total amount which may be transferred to the nonriparian.

This arrangement would allow a transfer of water from land where most of the time the marginal value in use of water relative to the costs of using it was relatively low to land where this ratio was higher. Thus, it has the potential to improve the efficiency with which water is allocated, particularly in areas where access to water is unevenly distributed.

Under this system, the DNR would retain the obligation of assuring that the use to which water would be put under each permit was reasonable. Administrative costs would be incurred in reviewing the application of the leasees. Such costs would have to be considered in light of the efficiency gains of the water transfers. Most of the responsibility for initiating and carrying out the arrangement would rest with the parties involved. The DNR would continue to retain its responsibility to see that the water source was not over ploited, and to protect the rights of third parties.

2. Sale of Water By Riparians to Nonriparians

A second approach, somewhat along the same lines as that suggested in 1 above would have the DNR granting permits to riparians which allowed the riparian to withdraw water for the purpose of selling it to other riparians or to nonriparians.

The reasoning behind this suggestions is as follows: a permit is in fact permission to withdraw water which is subject to modification by the DNR. Obviously this permission results in economic and other benefits to the riparian, even if he does not own the water.

Under the lease-easement arrangement discussed in 1 above, the riparian who leases land for his neighbors well has no control over the amount of water the neighbor withdraws. Thus, in a water-shortage situation, this tenant would be in competition for water with the riparian. This could tend to discourage such arrangements.

Thus, riparians might be more willing to participate in water transfers if they were given the right to obtain compensation for any reduction in their own ability to withdraw water resulting from the transfer of water. to nonriparians.

One way of doing this would be for the DNR to stipulate that the withdrawal of water from a given water source for the purpose of selling it to nonriparians was a reasonable use of the water and would, therefore, be permissible within the maximum withdrawal limits of the riparian's current permit. This permission could be conditional upon the types of uses the transferees made of the water, although from the standpoint of efficiency, this would not be necessary.

It would be necessary to provide some protection for the transferee against unfair practices by the riparian seller. In particular, the transferee could make large investments in irrigation equipment expecting to receive water at a particular price and then find that the price had been raised precipitously after his investment had been made. This problem could be avoided by adequate contractual safeguards; however, the contract would have to be contingent upon the DNR's right to manage the maximum amount of water which could be withdrawn under the riparian's permit and its right to modify that amount or to not grant the permit at all.

The main additional administrative cost of this approach would be for processing applications to sell water if such applications were deemed necessary so that the DNR could scrutinize the nature of the uses to be made of the trans ferred water by the transferees. In considering this option further, a determination would have to be made concerning whether such additional costs would be worth the benefits of moving water from less productive to more productive uses.

Clearly the legal and constitutional implications of this proposal would have to be explored in depth in its further consideration. In addition to constitutional questions raised by the proposed transfer of water from riparian to nonriparian land, the question can be asked as to whether the permission to sell water implies ownership of the water on the part of the seller. It could be argued that it does not because the state retains ultimate control through its ability to modify the terms of the permit which the water seller must have.

A second issue concerns the doctrine of reasonable use. Under this arrangement, the DNR would delegate control over the distribution of the water allowable under the permit among the riparian and those to whom he sold water. The DNR would make a determination as to whether or not the types of uses made of the water were reasonable but would make no such determination with regard to the quantities of water going to each use. The question arises, "can the DNR determine that use made of the water is reasonable if it does not know the exact amount going to each use?" It can be argued that by promoting the more efficient use of water, this option will lead to the more beneficial use of water than under the current system where the DNR puts a limitation on the quantity of water withdrawn by each specific user. In other words, that water that is efficiently allocated is more reasonably used than water which is not.

3. Mutual Water Companies

One way in which nonriparians could take advantage of either of the previous two options would be to form mutual water companies. Such entities exist in California and are a means by which any number of land owners may secure and distribute a common water supply. (Bain et. al., pp. 79 and 342 - 343.)

A newly formed mutual water company could secure a water supply by either buying or leasing riparian land, or by contracting to purchase water from a riparian land owner if this were permitted. The mutual water company would issue shares, each entitling its owner to some share of the water which the company could withdraw by virtue of its permit, or could purchase through option 2 above.

The shares would not imply that the shareholders owned the water but rather that they owned the mutual water company and had the right to use a percentage of the water withdrawn by the mutual water company by virtue of its permit or by virtue of the permit of a riparian land owner who sold the water to the mutual water company.

The shares would be traded on the market so that a competitive price could be administered by the staff of the mutual water company. As with the joint permit share trading option, water would be allocated to those uses which were at least as highly valued as the market price of the water, so that an efficient allocation among the members of the mutual water company would be established.

Such an arrangement would also promote efficient allocation because it would be a means of securing efficient transfers of water to nonriparian land owners.

The costs of administering and operating the mutual water company would be assessed against the shares of its members. Thus, it would be necessary to secure a sufficient number of members to prevent the cost burden on any single share owner from being too high. Nevertheless, this could be a viable means of securing water for nonriparians in areas where the geographical distribution of water was highly uneven. For such landowners, the benefits of having a reliable source of water could offset the costs assessed against the shares.

The same legal and constitutional questions discussed in 2 and, perhaps, additional ones could be raised with regard to mutual water companies. The DNR would have to delegate control over the specific quantities of water going to different users of the shareholders. Water would be transfered from riparian lands and permission to use it would be traded among the shareholders.

D. Zoning and Land Use Planning

One way to avoid putting too much pressure on surface and ground water sources during periods of drought and water shortage is to seek to locate new heavy water using industries in areas where water resources are relatively more plentiful.

There are, however, certain costs to implementing such a policy. Among these are the following:

1. Water is only one resource which is used in the production processes of industrial firms. Even if the cost of using water is high in an area because of limited water resource, a firm might choose to locate there because of the availability of raw materials and the relative costs of other inputs such as labor. Thus, if heavy water using industries are prevented from locating

in an area, the local benefits which might be derived from the industry are lost.

2. Use of water in the area by local residents and industries to the exclusion of industries which would locate there in the absence of zoning ordinances imposes a cost upon the excluded industries and their customers. Thus, the cost of the residents use of water is undervalued; that is, they do not bear the full cost of their usage and the allocation of water between these residents and local industries and the excluded industry is not efficient.

Prohibiting industries from an area which might otherwise choose to locate there constitutes an income distribution decision in favor of the local residents, and local industries and their customers, and against the excluded industries, its employees and its customers.

An argument for zoning can be made, however, on the negative basis that other water allocation options may not be applicable to a particular source for technical and/or political reasons. Zoning does provide a means of protecting against the possibility of over-committing available resources with resulting economic and environmental costs.

E. An Alternative Priority System

To correct for the problems of the present priority system discussed in Sections III. C, 2, and V.A. the following alternative priority system is suggested.

The purpose of this system is to deal with water shortages. It is not intended to be a system for granting permits or settling well-interference problems.

This priority system would consist of three main priority categories. In order of priority, these are as follows:

i. Basic Necessity

ii. Environmental

iii. Economic

These priority categories have the following features in common:

a. Each categories must be satisfied up to a minimum level of satisfaction before water use in a lower categories is permitted. Thus, the first two categories are not open ended, but rather, a ceiling is placed on water use in each.

b. During water shortages, enforcement of these ceilings is to be secured by compulsory measures where this is possible, otherwise moral suasion and education must be relied upon.

c. These provisions are to be applied on a regional basis when and where water shortage problems occur. The exact nature of these "regions" should be determined through further research.

d. Under this system, it would be possible for water users to have water demands in more than one priority classification. For example, a domestic user might have some uses which fall under class 1 and others which fall under class 3.

e. To the extent possible, the amounts of water consumption necessary for the fulfillment of the first two categories or for classes of uses within these categories should be estimated in advance on a regional basis with due consideration to interregional hydrologic relationships. Of course, adjustments would have to be made in minimum fulfilment estimates during the course of a water shortage.

Specific categories will now be discussed in more detail.

1. The Basic Necessity Category

This category would have priority over the others during a very severe water-shortage. It is doubtful that a water shortage would become so severe that this category would not be fulfilled; however, for contingency purposes and for completion it must be included. It consists of the minimum quantities of water per capita to sustain life and provide minimum levels of sanitation and electric power availability. Thus it would include the following uses:

a. drinking and sanitation

b. additional allotments for individuals with health problems which require them to consume more than the average amount of water.

c. electric power production to provide minimal electric power to homes, the municipal water works, hospitals and any other basic necessity uses if power cannot be imported from outside the area of concern.

d. other uses which are deemed basic necessities by the water allocation authority.

Currently the first priority in M.S. 105.41, Subdivision 1a is "Domestic water supply excluding industrial and commercial uses of municipal water supply". By itself, this priority is open ended and fails to recognize that among domestic water uses there are different degrees of necessity. However, this problem is somewhat ameliorated by M.S. 105.418 which states that

> "During periods of critical water deficiency as determined by the governor and declared by order of the governor, public water supply authorities appropriating water shall adopt and enforce restrictions consistent with rules adopted by the commissioner of natural

resources within their areas of jurisdiction to restrict lawn sprinkling, car washing, golf course and park irrigation, and other non-essential uses, together with appropriate penalties for failure to comply with the restrictions."

Under this priority system, a specific maximum for this category would be established in each water-use region (however defined). Water use beyond this ceiling would have to be justified on a case by case basis before additional use in this category could be given priority over uses in lower categories. The upper limit on the basic necessity category would then have to be raised accordingly. This approach could be more effective in limiting non-essential domestic uses than blanket curtailments of specific uses such as lawn sprinkling, car washing, etc.

Municipal water utilities and rural water-supply systems would be responsible for enforcing this priority among their customers. One approach they could use would be a strict rationing system with heavy penalties for customers going beyong their quotas. Such a system was used by the Marin Municipal Water District to cope with the droughts of the 1975-76 and 1976-77 seasons with excellent results. (Stroeh, pp. 21 and 22). Moral suasion and education would have to be relied upon to secure the compliance of self-supplied domestic users.

During an extreme water shortage, conservation in the use of electric energy could be as important as conservation in the direct consumption of water. Thus, an effective energy allocation policy would have to work hand in hand with water allocation policy.

2. The Environmental Category

The purpose of this category is to prevent the degradation of the environment. Thus, this category seeks to protect environmental assets that could be ruined for long periods of time to come without adequate water flows or levels.

In particular, this category includes the maintenance of instream flows for the maintenance of fish stocks. These stocks are necessary for recreational purposes and for environmental satisfaction.

In Working Paper No. 2, An Analysis of Instream Flow Needs in Minnesota (Gibson, p.18) it is recommended that

"...consumptive appropriators...be required to reduce or to stop water withdrawals when flows approach 10% of the average annual flow - the short term survival flow for fisheries."

Justification for this percentage may be found in the cited paper. The environmental priority class proposed here could incorporate such an instream flow requirement.

M.S. 105.417 Subdivisions 2-5 provide protection for instream flows and lake levels. Subdivision 2 requires that:

> "Where data are available, permits to appropriate water from natural and altered natural water courses shall be limited so that consumptive appropriations are not made from the watercourses during periods of specified low flows in order to safeguard water availability for instream uses and for downstream higher priority users located in reasonable proximity to the site of appropriation."

Thus, Working Paper No. 2 provides a "specified low" flow which together with the essence of Subdivision 2 can be incorporated into the environmental priority class.

The environmental priority class would also be concerned with the maintenance of lakes at minimally acceptable levels and thus would incorporate parts a and be of subdivision 3 or any successors to these parts suggested by the current water planning effort.

> "Subd. 3. Waterbasins. (a) Permits to appropriate water for any purpose from waterbasins shall be limited so that the collective annual withdrawals do not exceed a total volume of water amounting to one-half acre-foot per acre of waterbasin based on Minnesota Department of Conservation bulletin no. 25, "An Inventory of Minnesota Lakes."
>
> (b) As a condition to any surface water appropriation permit, the commissioner of natural resources shall establish an elevation for the subject waterbasin, below which no appropriation shall be allowed. During the determination of the elevation, which for the purposes of this section shall be known as the "protection elevation," the commissioner shall take into account the elevation of important aquatic vegetation characteristics related to fish and wildlife habitat, existing uses of the waterbasin by the public and riparian land owners, the total volume within the waterbasin and the slope of the littoral zone."

Given that there are already laws on the books protecting stream flows and lake levels, why should such protection be part of a priority system? There are two reasons for this. First, the priority system proposed here recognizes that basic human survival needs must take precedence over environmental needs in an emergency situation.

Secondly, specifying stream flow and lake level protection as part of a priority system provides explicit recognition that these needs must be considered in policies affecting the allocation of water among all uses.

3. <u>The Economic Category</u>

This category is very broad consisting of the water use of firms in various sectors of the economy including agriculture, manufacturing, and the commercial sector. It also allows for residential uses requiring water beyond that allowed in the basic necessity category.

Means by which water could be allocated among the individual uses in this category have already been discussed in previous subsections. These approaches or others could be applied at the regional level.

F. The No-Priority-System Option

An alternative to the current statuatory priority system and the alternative priority system offered in the preceding subsections is the alternative of no priority system. With no priority system, the allocation alternatives discussed above could be applied by themselves. If market approaches to water allocation were used, many luxury uses would be abandoned during water-shortage periods because they were less urgent and therefore less highly valued than alternative uses. Environmental assets could be protected by setting prohibitive prices when benchmark levels or flows were reached. On the other hand, the protection of basic necessity needs, environmental needs, and some sort of allocation among economic uses could be achieved by means of non-price rationing.

The main advantage of the priority system discussed in the previous subsection over no priority system is that the former would set up an explicit statewide value framework to which water allocation policies must adhere during water shortages. Within this framework, specific allocation policy could be carried out at a local or regional level.

G. The Omniscient Allocator Priority System

An alternative priority system which could be applied on a regional basis would be to establish relatively narrow priority classes based on estimates of the expected net benefits of water in alternative activities.

At this time, such an approach is infeasible. Conditions and, therefore, the net economic benefits of water use vary considerably among water users. The net economic benefits derived from the use of water in individual firms depend upon a variety of factors including the technical features of each firm's plant and equipment, the market position of the firm, economic conditions of the firm's industry, where the firm obtains its raw materials, and the specific hydrological features of the site at which the firm is located. These hydrological features can vary drastically, even in a circumscribed geographical area. Thus, generalizations concerning these conditions for the purpose of determing the net benefits of water use in narrow economic sectors are impossible. In addition, information concerning the quantitative nature of the benefits of water use through market channels is at best secondary and in some cases nonexistent.

In short, the necessary information for ranking narrow classes of uses is not available. Even if such rankings could be reasonably made, such a system would penalize relatively efficient users who deviated from the class average. Thus, efficient water users in classes deemed on the average to have low net benefits of water use would be unduly penalized if that class of users were given a lower priority.

It does not seem, therefore, that this approach to priority setting would be likely to yield efficient or equitable results.

H. Well-Interference Problems

In economic terms, well-interference problems may be described as follows: When an individual or firm decides to invest in a well, or, in the case of farmers, in irrigation facilities, it is because the individual or firm implicitly or explicitly expects a stream of benefits to arise over time due to the investment. If the individual or firm believes that the present value of this stream of benefits will be greater than that of the costs involved, the individual or firm will make the investment. But such investors may not always take into account all of the costs of their investments.

Consider, for example, a certain Farmer A who invests in an irrigation water-table well. Suppose his well, when operating, creates a cone of depression which extends under the property of his neighbor, Farmer B. Then Farmer A's well may result in costs which, in the absence of redress, must be borne by Farmer B if Farmer B has an existing well, or if B decides to put in a new well at a future date.

Suppose, for example, that Farmer B has an existing well. If Farmer A's well, when operating, creates a cone of depression which extends under B's well to a depth below B's drop pipe, then B will not be able to draw water from his well. To assure himself a continuously available supply of water from this well, B will have to incur costs such as lengthening his drop pipe, deepening his well, or drilling a new well.

If Farmer B does not initially have an existing well, but subsequently decides to install one, he will have to drill the well to a greater depth or take other measures in order to avoid A's cone of depression. In this case too, a cost is imposed upon him by Farmer A.

The task of mediating well-interference disputes often falls upon the DNR division of waters which is bound to seek settlements of such disputes within the limits of the current priority system and other legislation. Many problems mediated by the DNR have involved the alleged well interference by high yield irrigation wells on domestic wells. When it has been established that well-interference has actually occurred, these problems have generally been settled by compromise. The nature of the solutions has been that new irrigators have paid all or part of the costs of keeping older domestic wells operational.

Since, the interfering well is imposing costs upon the aggrieved party, it would seem to be most efficient and equitable for the interfering well-owner to internalize <u>all</u> of these costs. Efficient and equitable compensation should consist of two parts:

1. A once and for all compensation charge to pay for the added investment in a new or old well which is necessary to

obtain water given the cone of depression of the interfering well.

2. An annual charge to cover the extra energy expense of pumping water. Alternatively, the present value of expected future increases in these costs could be calculated and paid in a lump sum.

No compensation would be paid to owners of existing wells with drop pipes which already reached below the cone of depression of another well. If two wells mutually and simultaneously caused cones of depression which resulted in mutually added expenses to both, then payments under the above scheme would in part cancel out with the balance going to the party suffering the most expensive interference. When a well owner or potential well owner suffers interference costs due to the cones of depression of the wells of more than one other well owner, then the interfering well owners should split the cost of the compensation to the aggrieved party among them in proportion to the depth of the cones of depression for which they are responsible.

One issue often raised during discussions about well-interference problems is whether or not the owners of wells affected by interference should be compensated only above and beyond the costs necessary for them to make some "reasonable" or "best effort" to obtain water. In other words, in the case of water-table wells, should the owners be required to have some minimum well depth before they would be eligible for compensation?

It has been argued that such requirements are necessary, in order to prevent individuals from obtaining "windfall benefits" by presenting spurious complaints against irrigators and having free wells drilled for them or free improvements made on their old wells which they themselves should have made anyway in order to cope with naturally caused drops in the water table.

Obviously, more work is needed to flesh out this approach and to tailor it to hydrological reality and to the reality of hydrological information and to consider the legal implications involved. Nevertheless, the guiding principle would be that those who impose costs on others should compensate them as closely as possible to the extent of the costs imposed. For the reasons cited above, the operation of this principle could be made conditional on "reasonable effort to capture" by complaining well owners; that is, that they be compensated only over and above the costs of "reasonable effort to capture". Procedures for defining "reasonable effort to capture" under different hydrological circumstances could be established by the Department of Natural Resources. Note that this principle is independent of the use of the water which is pumped from the wells. This solution is efficient from the standpoint of the well owners as a group because each is forced to pay the full cost of his water use, including the opportunity costs imposed on others. Thus each will tend to use water to the extent that the marginal value in use to him is greater than or equal to the marginal cost of the resource used.

This approach would also tend to yield solutions to well-interference problems which would satisfy widely held values in favor of domestic use of water _vis à vis_ large irrigators. This is because domestic wells are relatively low capacity and usually don't interfere with other wells. This approach would usually result in such well owners being fully compensated for interference caused by high-yield wells owned by irrigators or others. Thus, its adoption would not necessarily require a great departure from current DNR policy. It would, however, set down a general rule for the settling of well interference problems. To be consistently applied, however, it could in some cases require a departure from the current priority system since the actual uses to which groundwater is put would largely be irrelevant to the operation of the principle that those who impose costs should pay for them.

VI. Allocation by Intermediate Water Suppliers

Included in the category of intermediate water suppliers are rural water systems and municipal water utilities. The phrase "water utility" will be used here to refer to either of these.

In general, water is allocated by water utilities by some sort of pricing scheme. These rate structures affect both the allocation of water within the service area of the utility, and at the sources from which it withdraws. There are, therefore, two reasons why these rate structures should be of concern if the maximum benefit from available water supplies in the state is desired.

1. Water delivered by water utilities directly provides satisfaction to individuals of households through its fulfillment of the personal needs and wants. It indirectly provides satisfaction to individuals by permitting firms to provide goods and services, jobs and income. The way in which this water is allocated within the service area affects the satisfaction directly and indirectly derived from its use.

2. The water utility acts as an agent for individuals and firms of its service area when it competes for water with other users (e.g. self-supplied industrial users, irrigators, persons using water for recreational purposes) at each of its sources. The rates charged by water utilities affect the total demand for water consumption by its customers. Thus, during water shortages, the total satisfaction of all users of water at or from each source depends on how water is allocated within the utility's service area.

In this section, suggestions are made for improving the rate structures of water utilities in order to obtain more efficient and equitable water allocation among their customers and at the source from which they obtain the water they deliver. No suggestion is made that the state should impose these structures on utilities although it might be desirable for the state to provide technical and financial assistance for their implementation should water utilities ever become interested in adopting them.

It is asserted in this section that current municipal rate structures are not efficient. Because, in general, water has been abundant in the State of Minnesota, the costs of such inefficiencies may not have been high so far. As the demand for water relative to supply increases in some localities, this could change. Perhaps the greatest cost of inefficient water allocation or, more specifically, the underpricing of water during peak demand seasons, lies in the resources devoted to unnecessary expansions which could be avoided if water were priced at its full value.

In any case, expected benefits of improving the efficiency of water allocation would have to be weighed against the costs, including the administrative costs, of doing so. One approach to determining the extent of these administrative costs and the benefits of the proposed changes would be to set up a pilot project whereby the state would help subsidize a particular water utility to undertake some of the changes suggested here.

A. Municipal Water Utilities

Within the State of Minnesota municipal water utilities are important withdrawers and allocators of water. Table 2 below indicates that 11.4 percent of the total reported water appropriations of Minnesota water went to municipal and other water works in the state. Table 3 shows that water works accounted for 49.6 percent of the water withdrawn from wells and, thus, were significant users of water from ground sources.

TABLE 2. Use of Reported Appropriations in Minnesota, 1976

Use	Percent of Total Excluding Hydropower
Cooling and Power Gen.	58.4%
Processing	21.9
Waterworks	11.4
Other Irrig. (Agr.)	4.5
Dewatering	2.3
Wild Rice Irrigation	0.6
Level Control	0.4
Air Conditioning	0.3
Temporary	0.2
Golf Course Irrigation	0.1
	100.1

Source: Water Planning Board Technical Paper No. 2, Table 4, p. 32.

TABLE 3. Breakdown of uses for each Source of Appropriated Power (hydropower excluded)

	Source			
Use	Wells	Lakes	Streams	Other
Waterworks	49.6%	4.4%	5.7%	0.2%
Cooling and Power Gen.	4.7	56.4	83.5	0.0
Air Conditioning	2.1	0.0	0.0	0.0
Processing	10.5	38.8	7.6	9.3
Temporary	0.9	0.1	0.0	0.2
Level Control	2.0	0.0	0.3	0.0
Dewatering	3.8	0.0	0.0	82.4
Wild Rice Irrigation	0.0	0.0	1.5	0.2
Golf Course Irrigation	0.6	0.1	0.0	0.4
Other Irrigation	25.9	0.2	1.4	7.4
	100.1	100.1	100.0	100.1

Source: Water Planning Board Technical Paper No. 2, Table 5, p. 32.

B. Rural Water Systems

A rural water system is a type of water utility which provides central water treatment and the delivery of portable water to homes, farms, and other establishments in rural area. The term "rural" as used here refers to small towns as well as to farms in the countryside. A major difference between rural water systems and municipal water utilities is that the rural water system tends to supply users who are much more widely dispersed. (Levy and Bruemmer., p. 2)

As of June 1978 there were two operating rural water systems in Minnesota, the Marshall-Polk and the Kittson-Marshall rural water systems; two systems which will soon be under construction, the North Kittson and the Rock County system; and one system which is still in the initial organizational proceedings, the Lincoln-Pipestone system. Each of the systems was organized under Minnesota Statute 116A and is being funded by the Farmers Home Administration. The Marshall-Polk, Kittson-Marshall, and North Kittson rural water systems are located in the northwest section of Minnesota in the Red River Valley. The North Kittson project began construction in the Summer of 1978. The Rock County system and the Lincoln-Pipestone system will both be located in the southwestern corner of the state. (Ibid., p. 8) For a more detailed discussion of these systems, and or rural water systems in general see Levy and Bruemmer.

C. Current Water Utility Pricing Practices in Minnesota

Water utilities in Minnesota do not charge for water consumed but rather for water delivered to each customer. Some water utilities also provide sewage treatment and charge for this service. Table 4 gives a summary of the rate forms used by municipal water utilities. The two operating rural water systems in the state use the flat charge rate form. The following discussion will focus on different types of rate structures for delivered water, however, the rate forms discussed are also applicable to sewage water.

1. Service Charges

Service charges are charges which do not vary with the quantity of water delivered. They are imposed in addition to per-unit water rates in a water rate structure. They are used to cover a portion of the capital costs of plant capacity and the distribution system as well as general administrative costs; costs associated with the number of connections such as billing costs, accounting costs, and meter reading costs; and equipment maintenance costs. One form of service charge is the minimum demand charge which is a flat charge for all water used up to a specified quantity.

2. Flat Charges

The flat charge is a fixed bill which is levied independently of the amount of water used, i.e., a customer pays a flat charge of $10 per month for water service. Flat charges are the second most frequently used rate structure. The prime advantages of this type of charge are that it is simple to implement and to understand, and very inexpensive to administer. This is due to the elimination of such costs as installing, reading, and repairing meters. A disadvantage of this structure is that it encourages the waste of water resources. Because consumers receive no price signals on the actual cost of service, there is no inducement to limit consumption.

3. The Single Block Rate

The single block or uniform rate is a constant rate charged per unit of water, i.e., the customer pays $2.00 for every 1,000 gallons of water consumed. This rate may vary according to different classes of users. The advantages of this rate structure are its simplicity and its ease of administration. If an attempt is made to equate the rate charged to each consumer class to the marginal cost of delivering the water to that class (including the shadow price of the water at the source), then the uniform rate can be highly conducive to efficient water allocation within the service area. Unfortunately, there is no evidence that such an attempt is ever made. Nevertheless, since the total water bill varies with the amount of water consumed, this rate structure can provide an incentive to conserve water.

4. Declining Block Rates

The most prevalent municipal water-rate structure in Minnesota is the declining block structure with a minimum demand charge. A declining block structure without a minimum demand charge is one by which a specified rate is charged per unit of water up to as specified amount of water consumed per billing period. Water consumed beyond this specified amount is charged a lower rate up to the next specified amount beyond which a still lower rate is charged. When this is combined with a minimum demand charge, the customer is billed a flat charge for all water consumed up to the first specified amount. Two reasons seem to account for the popularity of this rate structure.

a. The fixed costs of water utilities are very high compared with their variable costs (those which vary with the amount of water delivered). Thus, per-unit costs of water tend to fall until capacity is approached. Water utilities see it to their economic advantage to promote full use of their capacity. Declining block structures do this because the more a customer uses, the lower the average cost to him of the water he uses.

b. Water utilities seek to charge different groups of customers according to the costs they are believed to impose upon the system. Heavy water users are presumed to impose lower costs per unit upon the system because their use of water allegedly fluctuates less in time, and because of perdumed distributional economies (e.g., less piping material per rate of water use is required for heavy water users).

TABLE 4. Frequency of Water and Sewage Rate Forms, Comparison by City Size

Rate Form	WATER Small Cities %	WATER Medium Cities %	WATER Large Cities %	WATER Total %	SEWER Small Cities %	SEWER Medium Cities %	SEWER Large Cities %	SEWER Total %
Single Block	2.7%	5.4%	28.0%	4.8%	1.1%	7.0%	11.1%	3.4%
Service charge plus single block	0.0	1.0	5.5	.6	.5	4.3	0.0	1.7
Single block with a minimum charge	.9	0.0	0.0	.6	1.1	4.3	5.5	2.4
Minimum demand charge with a single block	.9	3.3	5.5	1.8	2.7	7.0	0.0	3.8
Declining blocks	10.3	15.0	0.0	11.1	4.4	11.0	5.5	6.5
Service charge with a single block	.9	9.0	16.6	3.9	1.1	2.0	5.5	1.7
Declining blocks with a minimum charge	.9	11.0	11.1	4.2	0.0	4.4	5.5	1.7
Minimum demand charge with declining blocks	47.8	51.0	33.3	47.9	27.9	22.0	11.1	25.1
Minimum demand charge with increasing blocks	.9	0.0	0.0	.6	.5	1.0	0.0	.7
Flat charge	27.7	4.3	0.0	19.7	57.4	37.0	55.8	50.9
Flat charge varying by number of residents	4.9	0.0	0.0	3.3	1.1	0.0	0.0	.7
All other forms	2.1	0.0	0.0	1.5	2.3	0.0	0.0	1.4

Source: Richard L. Gardner. An Analysis of Residential Water Demand and Water Rates in Minnesota. Bulletin 96. Water Resources Research Center. St. Paul, Minnesota. 1977. Table 3, p. 31.

From the point of view of the water utility, the first reason may be valid; however, the declining rate structure has the effect of encouraging high rates of water use.

The second argument has been disputed on empirical grounds by Bain et. al. (p. 357) who claim that in San Francisco "the ratio of average to maximum daily demand is almost the same for residential as for commercial and industrial customers." They cite the case of the Alameda County Water District where most large industrial users are largely self-supplying using the district's supplies as a supplementary source. Thus, their use of water fluctuates more than that of residential users.

> "Of course, the relevant factor is not the variation in demand of the respective classes but the demands placed by each group at the time of peak utilization. If residential demand during the peak demand period were far more uncertain than industrial demand, requiring greater reserves to be held against it, then costs could justify a price differential. But this differential would not extend to nonpeak periods, in which a uniform price should be exacted from both groups unless other cost differential are present." (Bain et. al, p. 357)

The authors concede that distributional economies probably exist for delivering water to large industrial customers; however, the authors note that "the distributional reservoirs and pipelines systems of most water systems provide integrated service to these two customer groups and the costs of serving them cannot be separated."

5. Increasing Block Rates

This type of rate structure is the reverse of the declining block structure. In this case, the price charged increases with successive blocks. This structure is useful for promoting water conservation; however, it is not likely to be efficient since this block structure does not reflect the actual marginal cost of delivering water to defined groups of customers.

D. The Inefficiency of Current Rate Structures

The current structures of municipal water rates tend to lead to the inefficient use of water and to unnecessary capacity expansions which are a wasteful uses of economic resources. These consequences are brought about because the existing rate structures are not directly based upon the short-run marginal cost conditions of supplying water to individual users, and because they do not reflect differences in these conditions among uses and users.

1. Failure to Distinguish Cost Differences in Space

The further a customer is from the point of distribution, the greater the variable costs of delivering water to him. This is due largely to the greater energy costs incurred in pumping water a further distance. Since rate structures do not allow for these cost differences, we have in effect a situation where users near the point of distribution subsidize users farther away. Thus, excessive water use in these areas is encouraged and another incentive for urban sprawl is provided. (Davis, et. al., Chap. 3, p. 15.)

2. Failure to Distinguish Cost Differences in Time

Water use in municipalities and rural areas tends to fluctuate hourly, weekly, and seasonally. During peak periods, the short-run marginal cost of supplying water to individual users is higher, primarily due to the larger amounts of energy needed to pump the water through the system. Another cost is that during these periods customers may be confronted with highly inconvenient losses of pressure. Since the rate structures fail to distinguish between these cost differences, non-peak users (those who tend to use water more during non-peak periods) subsidize peak users for the extra costs the latter impose upon the system. Thus, uneconomical use of water during peak periods is encouraged and political pressure mounts to expand the system when the loss of pressure during peak periods becomes intolerable or when researchers' "requirements" forecasts claim it is warranted; even though the rates that people would be willing to pay for peak-time water would not justify the expansion. To put it another way, because peak-time water is underpriced, resources are devoted to expanding water-works capacity, even though these resources are valued more highly in other uses. (Davis, et. al., Chapter 3, pp. 18-25)

E. An Alternative Approach to the Water Rate Structure of Intermediate Suppliers

This section is concerned with presenting an alternative water-rate structure for intermediate suppliers which is essentially a synthesis of recommendations for more efficient water pricing which are found in the literature on the subject. This approach is based on the marginal costs imposed upon the systems by identified groups of users. If it were possible to disregard the administrative costs involved with rate setting and bill collecting, then it would be most efficient to impose upon each individual connection charges equal to the marginal costs imposed upon the system by that particular connection. Of course, from an administrative standpoint, this would be impossible, so it is necessary to lump users into groups according to where and when they tend to use water. Those who use water during peak periods impose higher marginal costs upon the system than those who do not. Those connections located at points further away from the point of distribution, or at higher elevations tend to impose greater costs upon the system than those who live closer in or at lower elevations. Identified groups, therefore, consist of customers who impose similar costs upon the system; that is, there will be more similarity among the customers within the groups than among customers of different groups.

The rate structure imposed upon these groups for delivered water should consist of three parts: Initial charges, service charges and commodity charges.

1 Initial Charges

Initial charges should cover those increments to the costs of the system which can be attributed to each new connection. Thus, they should include connect charges and marginal capacity costs. The connect charges are designed to cover the costs of installing a meter, the cost of the meter itself, and the cost of adding a new customer to the accounts. Part of the initial charges should be used to cover the marginal capacity (both distributional and storage) costs associated with different classes of users which cannot be recouped on the basis of short-run marginal rate setting.

Because water utilities are obligated to supply water upon demand, they must keep adequate storage and distributional facilities to supply the peak demands of groups of users. Thus, in addition to the capacity required to supply average use, they must have adequate capacity to supply greater average use during the summer months, plus the capacity to supply hourly peaks which result from the use of water for lawn sprinkling and air conditioning. Beyond having the capacity to supply these needs, they must also have adequate capacity in reserve for fire protection.

Disregarding momentarily the subject of fire protection, if it were possible to vary rates over all peaks, hourly as well as seasonal, efficient economic pricing policy would call for the setting of rates during each period equal to the short-run marginal costs of delivering the water. Investment in capacity to meet peak demands would occur when the rates charged in peak periods justified using other resources to produce this capacity; that is, when the returns, as determined by the rates, covered the costs of providing the capacity.

Although it is quite feasible to charge different seasonal per-unit water rates, it is not practical to vary rates according to hourly peaks. To do this would require expensive time-of-day metering. Furthermore, the use of water for fighting fires is not governed by water rates.

It is possible, however, to determine for each identified group of users the expected maximum peak demands of the group. Thus, one can determine for each group possible marginal contribution to the capacity which must be set aside to meet peak hourly demands for such uses such as air conditioning and lawn sprinkling, and to the needed capacity for fire protection.

From an economic efficiency standpoint, the best way to recoupe the costs of these facilities is to charge each group of users a lump sum amount (which of course can be amortized over several billing periods) equal to the marginal increment to the cost of these facilities attributable to the group. An estimate of this for each group can be obtained by:

a. calculating the difference between the specific peak demand of the group and the sum of average demand plus other potentially coincidental peak demands, and

b. estimating the cost of the excess capacity required to supply an amount of water equal to this difference. (Hirshleifer et. al., p. 101 & 102.)

In essence the water utility is selling "options" on water to meet these needs. What is being suggested here is that the marginal cost of providing these "options" should equal the willingness of consumers to pay for them. Thus, we have another application of marginal cost pricing. In this case, the price is the lump-sum charge per unit of capacity provided.

2. Service Charges

The service charge is designed to

a. cover the fixed costs of the water utility directly attributable to each individual connection,

b. cover the ongoing marginal costs of maintaining capacity for the peak needs of the identified groups, and

c. distribute the economic losses or gains of the water utility.

In addition to selling delivered water to each connection, the water utility may be though of as providing the means by which that connection may receive water. Thus, it seems reasonable that the user pay a charge equal to the marginal cost of providing that connection. Part of this marginal cost is once and for all in nature and is to be covered by (part of) the initial charge. Another part is ongoing in nature and consists largely of the cost of meter reading and billing.

Likewise, part of the costs of providing an option on water for periods of peak use and for fire protection is ongoing. This would consist of the costs of maintaining the storage facilities and distributional capacity set aside for peak use of each identified group of users. These costs should be included in the service charge.

A third function of the service charge is designed to cope with the following problem: In certain circumstances, an efficient set of rates for water may entail an economic loss for the water enterprise due to the presence of excess capacity. The overwhelming majority of the costs of a water-supplying enterprise are fixed. Thus in the short-run, as the quantity of water delivered increases, average costs are falling and begin to rise only as capacity is approached and the rise in energy costs per unit overtakes the fall in fixed costs per unit. Consequently, the water utility cannot cover its costs unless it operates at a high level of capacity. From society's standpoint, the optimal rate, output (water delivered) combination is that at which the marginal cost of the utility equals the marginal benefits of the consumers. At that output, rate combination, net benefits over costs are maximized; however, the utility itself may not capture enough of these benefits to cover its costs unless it operates at a higher, less optimal level of capacity utilization.

One approach to allowing the utility to operate at an optimal rate, output combination and still be solvent is to seek to capture for the water utility part or all of the consumer's surplus. Consumer's surplus may be defined as the difference between the total amount consumers would pay for a given quantity of delivered water, and the amount they actually do pay. The portion of total consumer's surplus going to any single consumer increases with the amount of water delivered to him. Thus, one way to distribute the loss among consumers is to apportion the loss according to historical quantities of water used by the identified groups. (Hirshleifer *et. al.*, p. 92)

Another interesting approach towards covering the water works' loss with relevance to urban areas has been suggested by M. Mason Gaffney. (Gaffney. p. 204-208) He would try to capture a portion of consumer's surplus through an *ad valorem* property tax (presumably on top of any existing property tax). Land owners closer to the point of distribution would be faced with higher tax rates than those further away. According to Gaffney, this scheme has two major advantages.

As we suggest below, Gaffney would have individuals further from the point of distribution paying higher water rates than those closer in. This would take into account the higher costs of transporting water to the former. Thus, if the conditions of demand are similar for the two groups, individuals and firms closer to the distribution point would have greater net benefit than those further away.

> "With the land tax proposal, the consumer who senses a surplus for him at certain water rates steps forth and identified himself, and quantifies his surplus for us by his bidding for land served by our water system." (Gaffney, p. 207)

Thus, under this scheme those who had the greatest consumer surplus would pay the greatest property taxes and bear a larger portion of the water utility's loss.

A second advantage of Gaffney's approach is that it would reduce urban sprawl. Assuming that the point of distribution is near the center of the municipality, there would be a greater incentive to more intensively develop the land there in order to spread the higher tax out over revenues derived from uses of the land. The political feasibility of establishing new property taxes at this time, however, is questionable.

3. Per-Unit Commodity Rates

A per-unit commodity rate is the rate charged for each unit of water delivered. Commodity rates should reflect as accurately as possible the "true" short-run marginal costs of supplying water to groups of customers.

The short-term marginal costs of delivered water can logically be divided into two major components: The direct short-term marginal costs of the water utility resulting from expenditures on energy, labor, chemicals and other inputs which vary directly with the amount of water delivered and the shadow price of water defined in Section II. A.

In Figure 1 below, the curve labled MC represents the average direct marginal cost schedule facing an identified group of users during a particular season. This curve may be empirically estimable based on historical accounting data kept by water utilities. It is an "average" marginal curve because:

a. it is averaged over individual connections in the identified group, and

b. it is averaged over different hydrological circumstances facing the firm within the season.

Let us assume that an allocating authority charges price p for water consumed at the source. Then the curve labeled MC^1 represents the marginal cost curve of delivering water to the group of consumers including the shadow price of the water.

The curve DD gives the aggregated demand schedule for water for all water users during the season. The optimal rate to charge members of this group is r. At that rate Q gallons of water per day are delivered to members of the group. If a lower rate than r is charged, then a quantity greater than Q will be delivered. But the cost to society for each additional unit beyond Q exceeds the benefits to society. Thus a rate greater than r and the quantity delivered at that rate cannot be efficient. If a rate higher than r is charged, then some quantity less than Q will be consumed. Then each unit consumed beyond this quantity up to the quantity Q will produce more benefit to society than cost. Thus, only the rate/quantity combination r, Q is efficient.

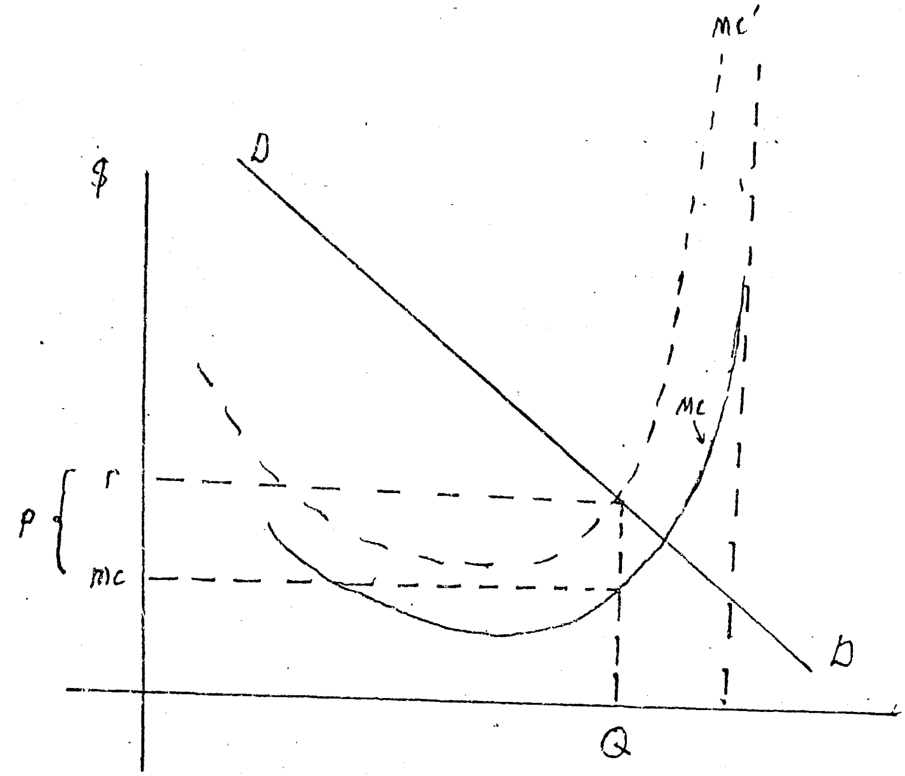

Figure 1

During the summer season when water tables tend to be down and stream flows are below average, the marginal cost schedule can be expected to lie above that for the winter season; that is, at every level of water consumption, the marginal cost of delivering the water is higher. Thus, the optimal rate for the summer season is higher than that for the winter season for each group of customers. This is a form of peak load pricing.

Note that seasonal rate differentials should have the effect of discouraging water use during the dry periods. On the other hand, there is no provision to use rates to discourage water use during peak hours of the day in either season. We already recognized above that this is not practical. As an alternative, it was recommended that part of the fixed initial and service charges be used to recoupe the cost of providing extra storage and delivery capacity to meet hourly peak demands.

The marginal cost schedule for groups of customers living far from the point of distribution will be greater than that for customers living closer provided, of course, that the latter are not on the average at higher elevations than the former. Thus, the optimal rates charged the latter group should be lower than those charged the former group. Similarly, on the average, rates charged customers at higher elevations should be greater than those charged customers at lower elevations.

The recommendations implied by the foregoing is that per-unit rates should:

a. equal the average seasonal marginal cost (including the shadow price) of supplying water to specific groups of customers, which further implies that,

b. rates should be higher during "dry" seasons than during "wet" seasons,

c. rates should be higher for groups of customers at relatively higher elevations and at locations relatively further from the point(s) of distribution.

F. Allocation by Water Utilities During Water Shortages

If the authority allocating water at the source from which the utility obtains its supply institutes a policy of benchmark water-shortage pricing during a water shortage (see V. B,2 above), a water utility may pass on these per-unit charges to its customers. This policy would tend to be efficient since it would tend to cause each of the users to cut back on his water use until the marginal value in use to each customer equaled the (new) price per unit which he paid for the water.

A water utility whose water consumption is limited by rationing could also allocate its limited supply among its customers by raising its unit prices for water or instituting a unit price where none existed before (some utilities rely on flat rates which are independent of the amount of water delivered to their customers).

Alternatively water utilities could ration water among their customers on a pro-rata or per-capita basis. As with the rationing of water at the source, there is no reason for such a policy to be efficient unless free trade in water rations is allowed.

One frequently used approach is to ban specific types of uses during droughts such as lawn sprinkling, car washing, and others. In fact this approach is specifically allowed for in Minnesota Statute 105.418 (see Section VII. A.1).

In an emergency situation, a system of pro-rata rationing combined with stiff penalty charges can be an effective way of reducing water use. This was done by the Marin Municipal Water District during a very severe drought in California in 1977. Each person was allotted 40 gallons per day. The charge per connection for water used within this allotment was $1.22 per 100 cubic feet and over double the allotted amount the charge was $50 per cubic feet. The policy was designed to cust delivered water by 57 percent. During the Spring of 1977 delivered water was actually reduced by 74 percent. (Stoehr, pp. 19 & 20.)

G. Water Pricing and the Distribution of Income

One problem which frequently is brought up during discussions of resource allocation concerns the impact of allocation policies on people at the lower end of the income scale. The imposition of marginal cost pricing is seen to put undue financial pressure on low income groups.

However, when water is inefficiently allocated because users do not pay for the full costs of their water use, including the opportunity and externality costs imposed on other users, then they are in essence subsidized by those who suffer these external and opportunity costs. There are two problems with this situation.

1. The brunt of these costs are placed on specific individuals and groups who are affected by the externalities and opportunity costs. If public concern that the water use of the poor should be subsidized is justified, why should the costs of this subsidization fall solely upon these individuals and groups?

2. The poor are not the only ones who are subsidized by inefficient allocation policy. Individuals and groups who could well afford to pay all of the costs of their water use are also subsidized.

Thus, it would seem to be more efficient and equitable to institute marginal cost pricing of delivered water and to subsidize low income groups in a more forthright manner.

One method of subsidizing low income groups which has received some attention lately is to establish a lifeline budget rate. The lifeline rate involves identifying a minimum necessary service requirement and a low monthly charge for vital consumption.

There are some difficulties with this rate structure, however. First low income users may be excluded if they reside in non-metered dewelling units or if their consumption exceeds the established minimum service requirement. Second, if the rate is structured so that all users qualify for lifeline rates regardless of monthly usage, affluent as well as non-affluent consumers will benefit. Third, the revenue lost to the system through the provision of low income support must be generated from other sources. This extra revenue can either be obtained from higher rates on consumption beyond the lifeline block and/or from higher commercial rates. However, if most users of a water utility are in low income categories, it may be difficult to generate enough additional revenue to cover the total costs of the water system (Mann, pp. 37-42).

If the lifeline rate is applied to only a small percentile class consisting of the lowest income families, with marginal cost pricing applying to all other users, and to low income families beyond the minimum necessary service requirement, then this approach could provide a means of achieving efficient allocation with subsidization for equity purposes.

An even more efficient approach would be to give low income families a lump sum cash subsidy each billing period equal to some fraction of the value of the minimum necessary service requirement valued at the marginal cost rate. Then these families would be charged the full rate for their water use. Thus, the low income families would be induced like everyone else to take into consideration the value of the water they were using, yet their basic needs would be provided for.

Another approach which has been suggested is to issue or sell at low price utility stamps to low income families. This alternative would not have the advantage of inducing these families to take into account the full value of the water used.

H. Intermediate Water Suppliers as a Means of Efficiently Allocating Water at the Source

Intermediate water suppliers including rural water systems, can provide a means by which water at the source is more efficiently allocated. They can do this in several ways:

1. Intermediate water suppliers can transport water from places where its marginal value in use is low relative to the costs of using it to places where it is higher helping to equalize its marginal value in use and thereby increasing the overall efficiency of water allocation according to efficiency guideline number 1 (Section II. A).

2. An intermediate water supplier can achieve efficient allocation among its subscribers by following efficient rate setting practices and monitoring the amount of water consumed by requiring meters.

3. Establishing intermediate water suppliers can have the effect of reducing the number of water withdrawers at a source and thereby of making the allocation of water at that source more manageable.

4. Rural water systems reduce the possibility of well-interference problems between domestic well owners and irrigators since the former can depend on the rural water systems for their supply.

One feature of rural water systems as now constituted or envisoned could reduce their ability to bring about more efficient water allocation at the source. Most subscribers to rural water systems retain their own wells. Thus, if during a water shortage the rural water system were to raise its rates, these users would simply switch to their own wells, thereby defeating the purpose of the increased rates. One way around this problem might be to require that small domestic wells be closed as a condition for joining the rural water system. Potential members may be willing to make this sacrifice in order to enjoy the advantages of the system. Large irrigation wells would have flow meters and would be subject to the prevailing policy for allocation at the source.

In conclusion, the potential ability of proposed rural water systems to bring about more efficient allocation of water at the source should be given attention in considering the merits of such systems.

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