THE ECONOMICS OF WATER SHORTAGES IN OKLAHOMA: THE EMERGING ISSUES

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The energy crisis was the dominant resource issue of the 1970's. Several aspects of this issue will loom large in the 1980's, also. However, some observers are predicting that the energy crisis will be supplanted in some parts of the country by a water crisis of substantial proportions.

The energy crisis undoubtedly meant different things to different people. However, the most commonly expressed fear was that severe shortages would eventually occur. A similar fear characterizes many who perceive an impending water crisis, including state and federal water resource planners.

The spectre of water shortages is not the only important water resource problem in the Southwest, of course. However, its resolution often dominates official planning guidelines. Moreover, it gives rise to such a large research agenda, by itself, that it is given exclusive attention here.

The remainder of this chapter is devoted to a discussion of how economic analysis may be used to determine whether there really does appear to be a water shortage, and, if so, what the best means are for its resolution. Because we are more familiar with the dimensions of this problem for Oklahoma than for the other southwestern states, we confine our attention to the Oklahoma case. In doing so, we draw heavily for our description of the problem on the <u>Oklahoma Comprehensive Water Plan</u> (CWP), a document which outlines the view of the Oklahoma Water Resources Board (OWRB) of Oklahoma's water problems over the next 60 years (OWRB, 1980). Texas has a similar document, the <u>Texas Water Plan</u> (1968), which contains a view of the water shortage problem in Texas that is quite similar to the one developed in the CWP. Thus,

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much of the following analysis would be relevant to an evaluation of Texas water problems, although it could not be applied unchanged.

The Oklahoma Comprehensive Water Plan

To facilitate development of the CWP, the OWRB divided the state into eight planning regions--multi-county areas exhibiting certain similar characteristics in terms of climate, geography, hydrology, and demography. Each region was analyzed seperately to determine when and by how much projected water requirements would exceed currently developed supplies. Two seperate projections of water requirements were made. The CWP Committee, composed of representatives of the OWRB and personnel from other state and federal agencies, made projections for each of the eight planning regions (Northeast, East Central, Southeast, South Central, Central, North Central, Southwest, Northwest). In addition, local interests in Eastern Oklahoma submitted separate projections for the three eastern planning regions, (Northeast, East Central, Southeast).

A comparison of already developed supplies with either set of projections indicated that a "shortage" would appear in each region before the end of the planning period (2040). To determine whether a region could meet its own needs, potential supplies from intraregional surface and ground water development projects were estimated and compared with projected water requirements. It was determined that potential supplies in the three eastern regions would greatly exceed either set of projected requirements. However, potential supplies within the five western regions (South Central, Central, North Central, Southwest, Northwest) were projected to fall short of requirements, even after extensive intraregional water resource development. To meet the unmet needs of the five western regions, it was argued that water would have to be transferred from Eastern to Western Oklahoma.

The intraregional water resource development program envisioned in the CWP would attack the water shortage problem by increasing supply, largely through the construction of new reserviors, well fields, and pipelines. According to this plan, supplies could be increased in the three Eastern regions enough to meet requirements projected by the CWP Committee at an estimated construction cost of $870 million (1978 dollars). To meet the higher requirements projected by local interests, construction of the Eastern intraregional system would cost approximately $2,944 million (1978 dollars). Shortages could be mitigated in Western Oklahoma by intraregional development of new supplies. However, maximum development would cost $1,844 million (1978 dollars) for construction in the West, and shortages would still exist in each of the five western regions. In the Central region, the post-development shortage (largely municipal and industrial water) would grow to 487,000 acre feet per year by 2040. The post-development shortages (largely for irrigation water) would grow by 2040 to 798,900 acre feet per year in the Southwest region, to 947,100 acre feet per year in the Northwest region, and to 35,500 acre feet per year in the South Central region.

A large water transfer system was conceived as a means of closing the gap between requirements and fully developed supplies in the five western regions. This system would be composed of a series of pumping stations, canals, and reservoirs that would transfer water from Eastern to Western Oklahoma. The price tag for construction of this system was estimated by state and federal planners at $7.8 billion (1978 dollars). The addition of operation, maintenance, repair and energy costs would raise the total costs to $18 billion (1978 undiscounted dollars).

The principal message of the CWP is that there will be enough water in Oklahoma to meet projected requirements, and that these requirements could be met by a concerted, massive program of public works projects designed to develop new supplies. The wisdom of this message depends critically upon the accuracy of the underlying forecasts of water requirements, and upon the soundness of the proposed supply-enhancement strategy. It is possible to find fault with both the projections and the strategy.

Water planners make projections of long-run water <u>requirements</u>. Economists would like to see planning based on projections of long-run water <u>demand</u>, instead. The two efforts are designed to project future levels of water use, and both conceive of water use as determined by many of the same independent variables, such as population, income, employment, etc. However, demand projections, unlike requirements projections, would also include the impact of variations in water prices. Because there is an inverse relationship between use and price, requirements typically exceed demand in a context of rising water prices.

Would water prices be rising in the future in Oklahoma? If the CWP is correct in its claim that shortages would appear, the answer is probably "yes", because shortages, themselves, would normally trigger price increases. Indeed, prices would <u>stop</u> rising only when shortages no longer appeared.

Failure to estimate use and price simultaneously is common in water resource planning efforts, and constitutes perhaps the most important shortcoming of the CWP water projections. Simultaneous estimation of these variables would produce smaller projections of water use than those reported in the CWP.

One other relationship apparently understated in the CWP that could reduce projections of water use is that between water quality standards and water use. Water quality standards have been elevated considerably in the past decade, and may be elevated further in the future as the nation strives to achieve zero discharge of pollutants by 1985. In an attempt to meet these standards, industrial firms have greatly reduced water outflows, already. This has created a large reduction in water intake, as well. The full implications of these trends have not been included in the CWP projections.

Turning to the supply-enhancement strategy, two problems are apparent from an economic point of view. First, water planners have not established that the benefits of proposed development projects would exceed the costs of these projects. Second, it has not been established that traditional supply enhancement projects are superior to non-traditional supply enhancement strategies or to demand-management alternatives. Thus, even if the proposed intraregional development and water transfer projects are economically feasible, they may not be as attractive in an economic sense as other alternatives.

The principal tasks on the research agenda appear clear, then. There is a need for: (1) more imaginative water demand studies, (2) cost-benefit analyses of proposed traditional water supply projects, and (3) cost-benefit analyses of potential non-traditional supply alternatives and demand-management strategies.

A comprehensive economic demand analysis probably tops the list in terms of research needs. Such an analysis may severely temper our view of what really is needed in the way of solutions of any type. We know of no effort of this kind for any of the Southwestern states. If a comprehensive study is not possible, then smaller area studies should be conducted, concentrating first on those areas where critical shortages are likely to appear first (see APPENDIX A for a proposed study of this type).

In the realm of cost-benefit analysis, the large number of possibilities also suggests that research priorities will have to be established. Based on costs-benefit analyses done so far, we can probably eliminate only one project from the list--the proposed Statewide Water Conveyance System (SWCS). It is possible, however, to offer some suggestions for additional cost-benefit analyses. The remainder of this chapter is devoted to these issues.

The Statewide Water Conveyance System

In spite of the fact that the SWCS is only one of two general supply-enhancement programs outlined in the CWP (the other is the intraregional development program), it has received the lion's share of attention in the press. It has also been the principal subject of evaluation up to now.

A cost-benefit analysis of the SWCS was performed first by personnel from the Bureau of Reclamation, U.S. Army Corps of Engineers, and the O.W.R.B. The results of this study, reported in the CWP, indicated that the project would produce benefits only about one-third as large as costs. However, because this study employed federal government evaluation criteria, and it seemed highly likely that Oklahomans would pay virtually all of the costs, the O.W.R.B. commissioned a study by university economists in which the project was evaluated solely from the state's perspective (Kletke, et al., 1981; Liew and Liew, 1980; Olson, 1981a).

The results of the latter study are available in a report (Olson, 1981) and also in a journal article (Olson and Hibdon, 1981). A re-evaluation, incorporating a broader range of considerations was recently completed (Olson, 1982).

In this latest study, Olson begins by distinguishing between secondary (indirect) and primary (direct) benefits. Primary benefits are equal to the amount that home owners, farmers, and firms would be willing to pay for project water delivered directly to them. Primary benefits would arise also from project construction, but only to the degree that construction workers would be drawn from the ranks of the unemployed. Secondary benefits would occur, similarly, to the degree that otherwise idle resources would be employed--in this case, as a result of interindustry effects, or secondary impacts. These impacts would be initiated by: (1) purchases by construction firms of materials, equipment and services, (2) changes in household choices in the face of rising water prices, (3) changes in the production of primary agricultural commodities, and (4) changes in directly-affected industrial production.

The project would be feasible if the present value of primary and secondary benefits (PVB) exceeded the present value of costs (PVC). Present value calculations require use of a discount rate. Because the economics profession does not agree on the rate to use in cost-benefit analysis, the 1982 study employed three rates: .035, .065, and .09. The lowest of these is an approximation of the social rate of discount, as estimated by Gramlich (1981). The middle rate approximates the .06625 rate prescribed for federal water project evaluation in 1978 (the base year for evaluation of the SWCS) by the Water Resource Council. The high rate is an estimate of the before-tax rate of return on investment in normally risky private securities in 1978, based on procedures developed by Seagraves (1970).

The truly critical issue in many cost-benefit studies is that of the appropriate interest rate, because of the uneven phasing of benefits and costs over time. This issue is not nearly as important for the SWCS because both costs and benefits are spread relatively evenly over the lifetime of the project.

The critical determinant of the economic feasibility of the SWCS appears, instead, to be the proportion of the secondary impact that would count as secondary benefits. The key here, as indicated above, is the probability that resources required to support secondary impacts would be drawn from the pool of otherwise idle resources. There is not yet a technique available that allows one to estimate this probability accurately. However, what is known about the critical determinants of this probability seems sufficient to support the argument that secondary benefits are not likely to be large enough to make PVB>PVC.

To develop this argument Olson begins with a comparison which ignores secondary benefits; namely, PV of primary benefits minus PVC. The relevant estimates are depicted in Table 1. These estimates are Olson's high estimates of primary benefits and low estimates of costs; this pairing chosen to maximize chances of project feasibility. Column 4 shows clearly that the project would be unfeasible without secondary benefits.

The figures in column 4 also represent how large secondary benefits would have to be to make the project just feasible (PVB=PVC). Table 2 presents Olson's estimates of the PV of secondary impacts, calculated two ways: first, with only the usual input-output backward linkages, and then with forward linkages between feed grain production and feed lot production, in addition to backward linkages. These two estimates represent high and low estimates of secondary impacts.

Assuming the higher of these estimates (column 2) it is possible to calculate the proportion of secondary impacts that would have to be counted as secondary benefits to make PVB=PVC. These proportions are: 0.65 at a discount rate of .035, 0.73 at a discount rate of .065, and 0.87 at a discount rate of .09. According to a labor supply response function developed in Haveman and Krutilla (1968) the lowest proportion (0.65) corresponds to an unemployment rate ranging from 12 to 20 percent, while the highest proportion (0.87) corresponds to unemployment rates ranging from 16 to 23 percent.

TABLE 1

PRESENT VALUE OF PRIMARY BENEFITS AND COSTS
(Millions 1978 Dollars)

Discount Rate	Primary Benefits	Costs	Primary Benefits - Costs
.035	3,439.8	6,793.0	-3,353.2
.065	1,452.9	3,482.5	-2,029.6
.090	759.0	2,284.2	-1,525.2

TABLE 2

PRESENT VALUE OF SECONDARY IMPACTS
(Millions 1978 Dollars)

Discount Rate	With Forward and Backward Linkages	With Backward Linkages Only
.035	5,183.5	4,001.2
.065	2,762.4	2,152.0
.090	1,757.7	1,374.0

The probability that such unemployment rates would be experienced on a sustained basis over the 50 year project life seems extremely low. In fact, given the remoteness of this possibility, the comparison above of estimates of benefits and costs that are already biased toward feasibility, and the likelihood that water requirements exceed water demands, it seems safe to conclude that the SWCS is not an economically viable option at this time.

In a larger context, these results suggest that plans for large-scale, long-distance water transfer principally for agricultural use, should be replaced on the planning and evaluation agenda by more modest alternatives. There is a very large number of these alternatives. Each intraregional development plan contains several unevaluated traditional water supply projects. Moreover, for each such project there may be several non-traditional alternatives. The task of the future is to identify all promising alternatives, to evaluate them, and to compare them on the basis of rational criteria.

To illustrate what we mean here, two cases will be outlined below. The criterion used to choose these cases is their frequent appearance as items of discussion in the press.

Metropolitan Water Shortages

A close reading of the CWP reveals that the largest non-agricultural water shortage of the next decade or two is likely to occur in the Oklahoma City area. According to the CWP, conventional sources in this region are already nearly fully-developed, and future requirments will have to be met by importing water. Even waiving the question of whether water requirements projections for this region are accurate, one can have legitimate reservations about the wisdom of the importation strategy.

First, it should be acknowledged that water imported for municipal and industrial (Mand I) use (the principal type of shortage projected for Central Oklahoma) is likely to be more attractive economically than water imported for agricultural use. The reason for this is straightforward: the value of the marginal acre foot of water in Mand I use typically exceeds its value in agricultural use. Thus, Mand I water import projects will typically yield higher PVB than agricultural water import projects of equal size.

However, the critical question is whether PVB would exceed PVC for an Mand I project for the Oklahoma City area. At this point in time, we simply do not know.

The project discussed most often in this context is one which would transfer water from Southeast Oklahoma to Central Oklahoma via a system of pipelines, pumping stations and reserviors. The Corps of Engineers prepared a preliminary design of such a project for their study of the Central Oklahoma Project (COP), (U.S. Army, 1979). This project appears in modified form as one part of the SWCS.

The COP has never been evaluated adequately in terms of costs and benefits. The Corps assumes that PVB would equal PVC for Mand I water if the state of Oklahoma is willing to finance the Mand I portion of the project. A preliminary comparison of PVB and PVC of this component of the SWCS was made in an evaluation of the entire SWCS (Olson, 1981), which showed that the COP may be feasible. However, this result depended heavily upon a highly uncertain secondary impact from municipal water use. Both this impact and the other benefits and costs of the COP require additional study before any definitive conclusions can be made.

Just as important, however, is the need for an economic evaluation of a host of alternative means of meeting or managing Central Oklahoma's water demands. There are other water supply alternatives, water demand management alternatives, and other policy alternatives that deserve more careful attention than they have received in the past.

The principal (but probably not the only) unexamined water supply alternatives are: (1) surface impoundment with desalination of water for household and industrial use, (2) surface impoundment without desalination for power generation and industrial use, (3) reuse of existing supplies by households, industry and agriculture, (4) leak detection and repair, (5) more extensive ground water development, and (6) reallocation of stream, ground water, and reservoir water rights.from low- to higher-value uses. The principal demand management alternatives are: (1) the adoption of more rational pricing structures and (2) the adoption of water conserving technologies. Two possible policies in the "other" category are: (1) stricter water pollution control, and (2) relocation assistance to individuals and enterprises adversely affected by water shortages. The common thread in all of the alternatives is that they offer a potential alternative to water importing that may be more viable economically--at least over some ranges of time and use.

There are a few promising sites for surface impoundment within the region; most notably, Seward and Crescent Reservoirs on the Cimarron River, and Hydro Reservoir on the Canadian River. However, the water which could be impounded at these sites would contain a relatively high concentration of total dissolved solids a large part of the time. Given the high costs of importing water, desalination of this water may be justified economically for some high-value uses. Alternatively, water of relatively low quality can be used for cooling by electric generating plants and some industries. Thus, impoundment for these uses could possibly release higher quality water for other uses.

constraints is unknown for the case at issue. Moreover, according to the CWP, large amounts of water in Central Oklahoma are dedicated via water rights assignments to irrigators (130,000 acre ft. per year) and industrial, commercial and power generating users (82,000 acre feet per year). Thus, this alternative seems worthy of further study.

On the demand side, water in Central Oklahoma, as elsewhere, is usually priced according to a declining block rate structure. Such pricing normally encourages excessive water use. In addition, water prices are not usually varied to match variations in costs necessary to service different classes of users, or to allocate scarce supplies until a new source is economically justifiable. This, too, encourages excessive consumption by certain classes of users; most notably, by summer-peak users and by users located in outlying areas served by a system.

In the absence of development of new supplies, it is reasonable to assume that prices would rise to ration available water. Rising prices would impose economic costs on water users; however, these costs may be less than those resulting from premature development of new supply sources.

Another demand management tool with some promise is the adoption of water-saving (conservation) technologies by households and firms. The alternatives here are quite numerous (see Moomaw, Mowen, Olson, 1979). If prices were increased, many water-conserving technologies probably would be adopted as a means of reducing water bills. However, conservation solutions could also be prescribed by government or subsidized by taxpayers as an alternative to increasing prices.

Finally, there are policies not normally identified as water management policies that may deserve careful consideration. One is a program of assistance designed to aid individuals and firms adversely affected by a water shortage. Another is a vigorous program of water pollution control. In the former case, subsidies required may actually be less than the subsidies required to support water importation. In the latter case, vigorous enforcement of water pollution standards may improve the quality of water enough in some reaches of the North Canadian, Canadian, Upper Little, and Deep Fork Rivers to make them more attractive water sources.

Each of these alternatives has been examined much more thoroughly in the literature. However, we are not aware of any effort to apply these findings to Central Oklahoma. Until there is such an application, the question of which strategy to pursue to relieve projected water shortages remains unresolved.

The water shortage for Central Oklahoma lies in the future. The Tulsa metropolitan area has already experienced such a problem during summer drought periods. Application of a methodology similar to the one proposed above seems in order here, as well. There are geographic, demographic and hydrologic differences between the two areas, of course. There are also some different alternatives available in the Tulsa area, such as scalping of high flows from the Arkansas to be stored for later release, or reallocation of storage in Keystone Reservoir. However, the perspective advocated above is useful primarily because differences exist between regions. Its chief virtue is that it emphasizes the question that is most in need of being answered; namely, is it true that traditional water supply projects are the best of the conceivable alternatives?

Water Shortage in the Panhandle

One of the principal objectives of the SWCS is to supplement or replace depleting ground water supplies presently used for irrigation. Approximately three-fourths of the water conveyed through the proposed system is intended for these uses. Paradoxically, it is the relatively low value of water in irrigation that makes it most likely that PVB<PVC for the SWCS.

Project proponents argue that if water is not transferred to the Panhandle, continued withdrawals from the Ogallala aquifer will seriously deplete the existing inventory of ground water and ultimately creat substantial economic decline. However, one of the studies underlying the cost-benefit analysis of the SWCS indicates that there would not be a decline in regional agricultural output in the absence of the SWCS (Kletke, et al., 1981).

Table 3 shows the agricultural future projected for Northwest Oklahoma without the SWCS. Column 2 indicates that there will be a decline in irrigated acreage between 1985 and 1990. However, this decline is matched by a shift to dryland acreage (not shown). Given expected commodity prices, and the producitivity of dryland acreage, the value of farm output will not decline even with the rapid temporary decline in irrigated acreage over this period.

However, even if an actual decline in output would not occur there may be an interest in reducing or eliminating the negative influence of the reduction in irrigated acreage (farm output would be higher than the projection in Table 3 if irrigated acreage did not decline at all from 1985 to 1990). Given the hydrology and geology of the Panhandle little relief could be provided by additional surface water development within the region. The only site with significant yield potential is Englewood Reservior on the Cimarron River in the northeast corner of the Panhandle. Although this site should be subjected to a cost-benefit evaluation, preliminary indications are that water quality may be too low to support sustained irrigated agriculture at reasonable costs (Olson and Holmes, 1978, Section 3).

TABLE 3

PROJECTED IRRIGATED ACREAGE AND FARM OUTPUT WITHOUT SWCS, NORTHWEST OKLAHOMA SELECTED YEARS, 1977-2040

YEAR	ACRES IRRIGATED	FARM[a] OUTPUT
1977	303,500	241.5
1985	382,500	333.1
1990	262,600	360.9
2000	320,800	380.6
2010	334,600	485.0
2020	348,400	589.4
2030	348,600	625.9
2040	348,900	662.4

[a] Millions of 1978 dollars.

Source: Kletke, et al., 1981.

Demand management probably has far greater potential in this region then supply-enhancement. One promising alternative in the Southern Great Plains, in general, is investment in on-farm conservation measures, including (but not limited to) canal lining, piping, land leveling, improved methods of application, tailwater recovery systems, irrigation water management, and automation (U.S.D.A., 1979). Although these alternatives have been the subject of many studies, there is considerable room for specific applications of more general findings.

Another prospect for demand management is the rational pricing of ground water. Irrigators are currently granted rights to use, with a limit placed on annual withdrawals. These limits may or may not result in the optimal depletion of ground water stocks over time. If they do not, then a pricing scheme exists which would result in higher PV of regional income.

Finally, consideration ought to be given to evaluations of more general policy alternatives, such as relocation assistance, promotion of less water-intensive exports, or import substitues, and cash transfers to those with no feasible alternatives. Each of these policies would cost something, but the cost may be far less than the cost of water importation.

APPENDIX A

TOWARD IMPROVED METHODS OF FORECASTING MUNICIPAL AND INDUSTRIAL WATER DEMAND

A Proposed Study For
U.S. Army Corps of Engineers
Tulsa District

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TOWARD IMPROVED METHODS OF FORECASTING MUNICIPAL AND INDUSTRIAL WATER DEMAND

Accuarate forecasts of water demand are essential for water resource planning. Thye are critical to the decisions of whether to build a project, when to build it, and how large to build it. Growing scarcity of water, increasing conflicts over alternative uses, and more stringent budget constraints will require better forecasts in the future than have been needed in the past. This project is designed to complete preliminary work on an improved system of forecasting municipal and industrial water demand.

The proposed study will accomplish six specific tasks, each of which is described briefly below.

1. The determination of a set of demand forecasting equations for municipal and industrial water users, based on economic theory, in general, and on previous applications of this theory to the problem of forecasting water demand. Separate equations will be specified for subsets of municipal and industrial users where such specifications would increase accuracy in forecasting.

2. The determination of an appropriate range for values of the coefficients of the demand-determining variables developed in step 1. These coefficients (such as price and income elasticities of demand, rates of change in technology, population, income, employment, etc.) will be determined from an examination of previous studies and existing forecasts.

3. The development of a data base to be used for empirical testing of the equations specified in steps 1 and 2. These data will consist of historcal series of M and I water use, and of data series conforming to each

determinant of such use (as specified in task 1). The data will be developed for a set of water districts, chosen to be representative of variations in type and size of district.

4. An assessment of the forecasting equations specified in steps 1 and 2. This assessment will use data of step 3, plus other information, to determine how well the equations would have performed if they had been used in the past to forecast water use. Three "backcasts" of water use will be made and compared to actual water use (and to each other): a) one, using the coefficients developed in step 2 and actual values for the determinants of demand, b) one, using the coefficients developed in step 2 and projections of the values of the demand determiniants made by a variety of government and/or private sources, and c) one, using the demand forecasting procedures currently employed in Corps of Engineers project evaluation studies.

5. Modification of the initial set of forecasting equations to incorporate the findings of step 4.

6. Suggestions for policy analysts and planners, and identification of problem areas requiring additional research.

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