# COPING WITH POPULATION GROWTH AND A LIMITED RESOURCE [1]

546-72

By

Philip Briggs [2]

Wes Steiner asked that I express his regrets to you for his inability to be with you today. Negotiation of the contracts for delivery of Central Arizona Project water are at a critical stage and require his participation in Washington all this week. I know that Wes would prefer to be here. I asked him about the topic for my speech and what I should cover. He said ,"Don't worry about it, some really wild things are supposed to happen at these conferences and nobody pays too much attention to the speakers during the day". After many years of hearing these tales and being unable to participate he was looking forward to having an opportunity to find out whether Bill Horn and Fred Strauss were just pulling his leg. Seriously though, he has asked me to report that he had been looking forward to the chance to renew these old friendships; based on what he's told me I'm looking forward to the chance to make some new ones.

The assigned topic for the speech gives me a lot of freedom of content. I've decided to discuss with you two interrelated yet separate aspects of the work of my agency.

The first aspect has taken the majority of our staff time for the last three years and probably best fits the listed title of my discussion as it deals with the allocation of a limited resource among competing water users. The task is the preparation of the state's recommended allocations of the Central Arizona Project water to guide the secretary in contracting with the water users. In February of 1969 the Governor of Arizona requested that the Commission prepare recommendations for allocations that would maximize the benefit to the State of Arizona from the use of its remaining entitlement in the Colorado River. Expressions of interest in Colorado River water total over 5 million acre-feet, more than four times the Project's average delivery. Over seventy agencies are interested in contracting. In the spring of that year we contracted for the preparation of Plan of Study outlining a means of meeting the Governor's charge. A computerized systems analysis approach was proposed using an interlocking series of optimization and simulation models. The proposal was accepted by the Commission and for the next two years consultants served to develop a methodology, develop the models and train our staff in their use. The staff participated in the refinement of the models, collected most of the input data and by July of last year we were in full command of the system.

As we believe this to be one of the few applications of state of the art techniques to resource allocation by a state agency I would like to briefly outline the structure of the study for you.

Because the general problem of water allocation involves economic, hydrologic and engineering considerations, the analytical system was divided into three distinct, yet interrelated groups of models or sub systems: economic, hydrologic-engineering, and one which interfaces the first two. In addition to the basic data input, each of the models has the ability to incorporate realistic constraints, whether physical, economic, or social. In aggregate, the models consider a wide range of interrelated factors. Among them are availability, use and pricing of existing and future non-cap water supplies; hydrologic and engineering aspects of the State's water resources; the structure of Arizona's economy and its relationship to the rest of the nation; and relevant social and political preferences.

The first portion of the system is the economic subsystem which defines a future economy and calculates the total output of nearly 40 sectors of the economy and their demand for water. Given the water resources and the cost of supplying water within the state, it then calculates an allocation of water, by source, to each sector to maximize gross state product consistent with selected constraints. Selected output of the economic system is provided as input data to the integrated model.

---

1/ Presented at the Keynote Seminar, Western Snow Conference, Phoenix, Arizona, April 18-20, 1972

2/ Chief Hydrologist, Arizona Water Commission, Phoenix, Arizona

The second portion of the system is integrated sub-system which combines values and constraints generated by the economic and engineering models, and then determines water allocations within geographic areas modeled by the engineering system that maximize economic returns to the State of Arizona. In this process it considers hydrologic effects and water delivery costs as well as economic returns. The integrated model specifies allocations which are translated into demands for quantities of surface and ground water from various sources. These demands are imposed upon each geographic area modeled by the engineering system consistent with existing legal constraints.

The last portion of the system is the engineering sub-system which is used to simulate the operation of a specific geographic area. Hydrologic data inputs include total quantities of surface water available, groundwater quantities and pumping levels, opportunities for recharge and reuse of surplus waters. Engineering data inputs include capacities of the water delivery systems, construction and operating costs. As mentioned above, demands for water are described by the integrated sub-system. When these demands are imposed upon the modeled system, data outputs generated are the future groundwater pumping levels, costs of supplying both surface and ground water to meet the projected demands, required water transfer quantities within the area, amounts of reuse water, amounts of recharge and surplus or deficits of water within the system. Based on minimum delivery costs and given constraints, the model determines amounts of surface, ground and Colorado River water necessary to meet projected demands. These determinations then form the technical basis for the allocation proposals.

The three sub-systems fit together in a closed loop, the output of one being input to the other. Engineering data output serves to update economic input data and evaluate costs, both in dollars and resources, of a given allocation to meet projected demands. The models will be recycled until the inputs and outputs are internally consistent. Several sets of economic, engineering, social and legal constraints will be imposed upon the models, facilitating examination by the Commission of a range of alternative allocation policies. Consideration of all demands for water and all water resources within the state and a series of alternative ways of using those resources will better enable the Water Commission to recommend a plan for allocation of Arizona's remaining entitlement to Colorado River water that meets the Governor's request to assure that the recommended allocation "will be just and in the best interests of all of the people of Arizona."

We are all well aware of the growing awareness of the populace to its environment. One of the manifestations of this is the increasing demand for the state to exercise more control upon its development. We in Arizona are probably a year or so away from the beginnings of state wide land use planning. Until then, we will have to react to land use planning as established land developers. In Arizona, water rather than land, is the limiting resource and this brings us to our cooperative work with the Arizona Department of Health in evaluating the adequacy of water supplies for proposed developments. The Department of Health has the statutory responsibility to certify the water supplies adequacy both to quantity as well as quality but not the staff or the budget to adequately discharge the responsibility. Discussions between our respective staffs resulted in the arrangement whereby the Commission provides the technical expertise and manpower necessary to evaluate developments for which an approval was not intuitively obvious and or those surrounded with controversy. Currently, we are studying the Empire Ranch development south of Tucson. The water supply aspects of this development have been tried in the press and in front of various public agencies at great length; although the decision has not yet been reached I thought it would be of interest to you to describe our approach to the problem.

Our work on the CAP allocation study taught us a great deal about the applicability and limitations of simulation modeling of ground water systems. Partly because of the controversy surrounding the problem, and partly due to the intuitive, i.e. horseback hydrology, judgement that the development would have a major impact upon the ground water basin, it was apparent that the problem would require careful study, and that the long term effects would probably be more important than simply meeting the immediate demand for water. Thus we decided to model the ground water basin. While application of digital models to such problems in resource management is not new, it certainly is one of the few instances where it has been used by an action agency to make regulatory decisions; it is the first time in Arizona, and we will continue to use this technique as necessary in this continuing program.

Good basic data for the groundwater basin underlying the Empire development was rather scanty. Estimates of recharge, transmissivity, storativity and water levels in the basin as well as the effects upon the system of the proposed pumping program had been made by both protagonists in the controversy surrounding the development. Keeping carefully in the back of our mind the garbage in, garbage out axiom, we constructed a digital model using these estimates and operated it to simulate the basins current; relatively undeveloped state. To no ones surprise we found the basin as described by the estimated data, was not in balance. At this point we had already accomplished something in that we had demonstrated the potential errors in the use of the bank-book water budget technique in evaluating the effects of the development upon the basin.

Holding constant those items that we knew best, and varying the others within reasonable limits we continued to operate the model until it stabilized. Thus we do not feel that any one solution of the digital model has accurately simulated the status of the basin at a particular point in time, rather we are using the digital model to evaluate groups of a reasonable assumptions to prepare an array of results for use by the decision makers. We are looking for gross answers, order of magnitude approximations of the potential consequances of a given operations schedule.

We do not fancy ourselves as preservationists or champions of zero population growth; nor are we development oriented. We are attempting to reach an unbiased technical evaluation for use by the decision makers. We are working closely with the developer's hydrologic consultants, as the burden of proof of sufficiency is definitely upon the developer.

The Commission will advise the Health Department of the impact of the subdivision on the basins water supply and provide our judgement of the desireability of this affect. Bridging the gap between technical information and the resource management decisions required evaluation of many hard questions: What is a suitable lifetime for a municipal water supply and the city itself? 20 years? 50 years? a 100? And if the water supply does not dissapear but merely becomes more expensive through groundwater mining, what rate of mining is allowable? What is the practical limit for pumping lift? And when should the life of an ever growing city be measured - from the date of arrival of its first residents or the date of arrival of its last? Should that first individual be allowed 50 years or should the last be allowed 50? We have no glib answers to these questions, we are seeking guidance from municipalities and water utilities in Arizona and no doubt in the future we will have some guidance from the courts.