CHAPTER 5 -- CONCLUSIONS

The objective of this work was to test the hypothesis that institutional innovations for interstate coordination of surface water withdrawal and reservoir operations could promote more economically efficient spatial and temporal water use patterns as measures for coping with severe and sustained drought. We selected the following institutional innovations for evaluation: Law of the River, increased irrigation efficiency, carryover storage, and construction of new reservoir storage.

A three-state research team of economists, hydrologists and a lawyer was formed to perform the analysis. We developed a linked hydrologic-economic model that extends the basin optimization procedures developed by Vaux and Howitt for California (1984) and by Booker and Young for the Colorado River (1994). The modeling effort is limited to the Upper Rio Grande Basin, from Colorado through New Mexico to Fort Quitman, Texas, downstream of El Paso. Modeling of the lower basin, including water uses and inflows from Mexico, is not yet attempted. The general approach reflects the stochastic supplies and uncertain demands (from economic growth and endangered species policies) for water and river and reservoir management rules. Water supplies, which include all major tributaries and interbasin transfers, and hydrologically connected groundwater, are represented in an annual time-step over a forty-four year planning horizon. The baseline drought scenario used was the 1942-1985 period, which contained the severe drought of the 1950s and the very low-flow period of the late 1970s. Agricultural water uses, the major source of demands, are identified, including the San Luis Valley of Colorado, Middle Rio Grande Conservancy District of New Mexico, Elephant Butte Irrigation District of New Mexico, and El Paso Irrigation District of west Texas. Municipal and Industrial (M&I) demands for the Albuquerque and El Paso metropolitan areas are also represented. The optimization procedure, which minimizes economic damages subject to hydrologic, engineering and institutional constraints, is solved with GAMS-Minos optimization software. The overriding institutional constraint is the Rio Grande Compact, an interstate compact signed in 1938 by Colorado, New Mexico, and Texas.

Intrastate and interstate innovations in allocative institutions are tested against the baseline "Law of the River." Each institutional innovation was tested for robustness and economic efficiency under the 1942-1985 drought scenario. Results are presented as economic and hydrologic impacts of drought by state, economic sector, and institutional alternative for coping with drought.

This project has developed a model that responds to relative scarcity as those scarcities are reflected through compact deliveries and other institutions. While the model is not designed to generate the precise detail on how all of the institutions would respond and with what economic consequences, it is an important first step in bringing objective science to bear on important water policy decisions.

There is no issue more complex and more important to the people of the Upper Rio Grande Basin than understanding the hydraulic connection between the groundwater pumping in the region and the flows of the Rio Grande. Computer model results are not facts; they predict outcomes which may or may not ultimately be consistent with what occurs in the future.

In designing a drought model that predicts outcomes in times of drought, someone must make a choice. Or, at a minimum run a set of scenarios. Of course, too wide a range of scenarios is no prediction at all. Thus, we reluctantly conclude that hydrologic modeling is no less "certain" than economic modeling and is only as valuable as the accuracy of the assumptions that go into the model.

Improved modeling work in the future could support water policy decisions. For a model to be used with confidence by policymakers, it should contain:

- A mass surface water balance for the region studied so that when various rates of snow pack run off and flood events occur at the upper reaches and should reach the accounting point at El Paso.
- A set of hydrologic assumptions regarding the impacts of groundwater pumping on the system based upon the best data available using estimates that reflect good water conservation policy.
- A set of hydrologic assumptions regarding return flows, evaporation losses, transpiration losses, seepage and all other losses to the system.

- A set of institutional entitlements under the Rio Grande Compact that permit or do not permit storage and withdrawal at key points in the river such that one is able to estimate rates of flow at various points in the river system.
- A set of the best estimates of environmental needs in the river for rates of flow throughout the system that most closely resemble the traditional hydrograph, since these amounts will be required in the future by environmental interests.
- A set of anticipated consumptive needs throughout the system broken down by user and coupled with calculations of return flows from each kind of user.

The model developed for this study has built in most of these factors, at least in a rudimentary way. Important future model improvements would focus on relations between streamflows and environmental benefits of various kinds. Endangered species requirements and human values and benefits associated with those requirements are important issues that are largely untouched by this study.

Tied to the above outcomes as to where the water goes in times of shortage and to whom, is the kind of economic analysis contained in this final report that ties economic outcomes to water scarcity. This needs to be supplemented in future work by an analysis of the impact on water quality at various reaches of the river. Despite the considerable need for more refinement that will always be present in this kind of large effort, the drought study performed under this grant, we believe, is a step in the right direction.