Land Use, Population Growth, and Water Supply in Metropolitan Phoenix.

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A Systems Modeling Approach to Water Supply and Demand

Water Requirements in Greater Phoenix are sensitive to population growth, climatic uncertainty, future development, and allocation of natural resources. In turn, water demands must be supplied by water sources that are subject to complex regulatory and geophysical environments. This study presents a system dynamics model for water supply and demand in Greater Phoenix. The demand for water is generated by population growth, land use, land cover, and climate variability. Water supplies are Colorado River water delivered through the Central Arizona Project (CAP), groundwater, watershed, and recycled water. The model is presented within a decision-support framework designed to inform policy processes. In addition to modeling water at the systems level, this model provides a framework for detailed scientific studies at the Decision Center for a Desert City.

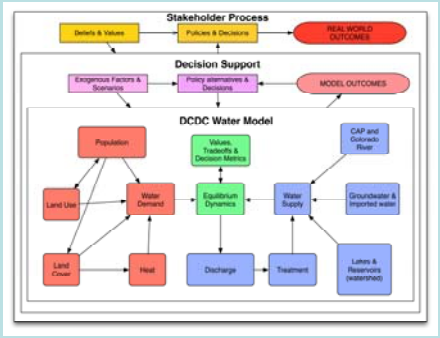

Figure 1. This diagram is a roadmap for integrating scientific knowledge and decision making. It incorporates both our goals of knowledge production and our work as a boundary organization.

Our vision involves three areas of basic research, involving climate change and variability, water decision making, and social vulnerability. An articulation of the interrelationships among these processes will result in the creation of decision support tools and scenarios of the future that, hopefully, will be the basis for informed public debate about water security.

Data & Model Validation

Water Duties: Water duties are defined as the average amount of water used for each land-use category. For example, table 1 shows that agriculture requires 3.56 acre feet per acre of land annually. Water duties used in this analysis were generated by CH2M Hill using 1995 data during a study for the city of Phoenix. These duties are applied to all land-use classifications and aggregated over the region to calculate water demand. SRP provided adjustments to the 1995 data to apply to 2000 land use categories as reported by the Maricopa Association of Governments (MAG).

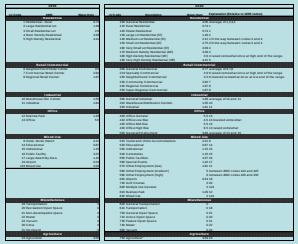

Table 1. Water Duties for MAG land-use categories in years 1995 and 2000. Data reflects the average amount of water used annually per acre.

Land Use: Land Use is reported by MAG for all cities and reservations in Maricopa County. We use maps generated from the 1995 and 2000 reporting periods. The 2000 General Plan reflects the general plans submitted by member cities. MAG also creates a "Future Land Use" map that reflects current knowledge about development projects in Maricopa County, but allocates land use into fewer categories. For this analysis, we use the general plan as the basis of our projections. Figure 2 shows land use for the 1995 and 2000 reporting periods.

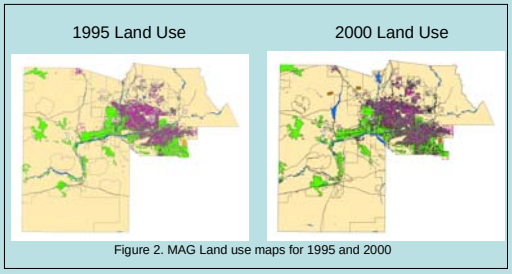

Figure 2. MAG Land use maps for 1995 and 2000

Model Validation: Actual water consumption corresponds closely to model results from the land use model. The model output is 2.42 m.a.f. compared to an actual value of 2.29 m.a.f. in 1995. The model output is 2.68 m.a.f. compared to an actual value of 2.35 m.a.f in 2000. This comparison is shown in Figure 3.

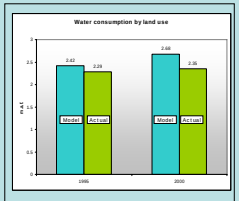

Figure 3. Actual and calculated water consumption using the land use data and water duties.

Prediction of future water demand

Two factors are critical to the prediction of future demand: the conversion of agricultural land to residential and the amount of water that other land types will consume. Low density residential land generally uses less than agricultural land, while higher density residential and office developments require more water. As of 2000, about 7% of land is classified as agricultural and nearly 45% of the land in Maricopa county is vacant. (See Fig 4.) Critical decisions about the use of this land will determine the stress placed on available water resources. Current assumptions about land use at buildout suggest that an additional 1.36 m.a.f. of water would be necessary. However, MAG general plan data allocates land to the rural-residential classification that accounts for 1.40 m.a.f. of the total demand of 4.04 m.a.f. at buildout (Figs 5, 6). In particular, note that all agricultural land is converted in the buildout scenario, except on Native American reservations. Figure 6 shows water demand for the buildout scenario.

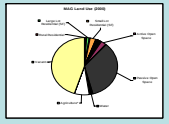

Figure 4. 2000 Land Use allocation by category.

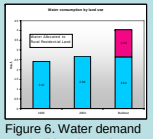

Figure 6. Water demand at buildout based on MAG buildout data.

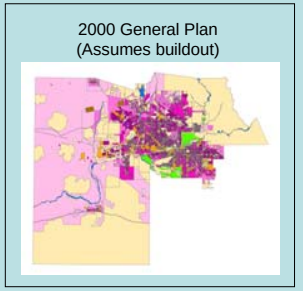

Figure 5. MAG general plan

Calibration with Population Growth

Land use is sensitive to population. Generally, water managers use rule-of-thumb estimates of water demand based on population estimates. The approach here is different: we calculate population based on land use-classification. Figure 7 shows average population per acre of land use type and population estimates based on 100% occupancy rates of zoned land. Error bars indicate the low- and high-end of each range.

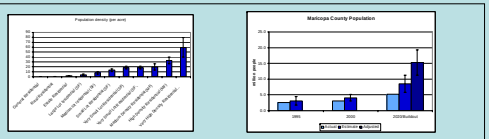

Figure 7. Population per acre by residential land use and total population by year.

Acknowledgment

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