# South Platte Regional Assessment Tool (SPRAT)

By Chris Goemans, Western Water Assessment

*This article describes the development of a regional water resource model capable of modeling the impacts of future population growth and increased climatic variability on water users throughout the South Platte River Basin.*

**Why Develop a Model of the South Platte?**

Located in the northeastern corner of Colorado, the South Platte River basin (South Platte) is unique in that it serves both the most populous section of the State and includes the nation's third largest irrigation system. Between 1950 and 2000, population in the South Platte basin nearly tripled, increasing at an average annual rate of 2.7 percent per year. As of 2000, total population within the basin exceeded 2.9 million people. This growth is expected to continue with total population projected to more than double by 2050. Population growth, combined with the recent drought, has highlighted the need for a better understanding of how future changes to the South Platte will affect water management within the region and for exploring the potential benefits and interactions of various management options designed to reduce vulnerability to shortages.

Several large water providers throughout the Basin have developed sophisticated models specific to their management areas, however, a regional model of the South Platte capable of analyzing the effects of continued growth, and/or increased climatic variability, on water users throughout the Basin does not currently exist. This shortcoming is not unique to the South Platte. Throughout the Southwest, it is common for water supply projects to be evaluated from only a local perspective without consideration for the long-term impacts to other areas, users, and proposed developments within the basin (Dai and Labadie, 2001). Planning efforts utilizing a narrowly focused "safe yield" process focus often ignore these other considerations and interactions when calculating the physical ability of a particular project to meet specific forecasted demands under a drought of record. This shortcoming was illustrated during Colorado's recent Statewide Water Supply Initiative (SWSI), which reviewed dozens of individual water plans to assess future water supply conditions on the regional scale, concluding:

> *During the SWSI process, it became apparent that many water providers had identified the same sources of water and there may not be adequate supplies to meet the needs of the various providers. (Colorado Water Conservation Board, 2004: 6-3).*

**South Platte Regional Assessment Tool**

The South Platte Regional Assessment Tool (SPRAT) was developed by the Western Water Assessment to address regional water supply vulnerabilities in a coordinated way. SPRAT models the allocation of water throughout the South Platte basin with respect to current physical, institutional, and environmental constraints, as well as under future scenarios that include population change, climatic variability, and changes to infrastructure. In addition to assessing vulnerabilities, the model provides a mechanism for exploring the potential benefits of various management options designed to reduce vulnerability. For example, SPRAT can be used to obtain a better understanding of how future droughts of various lengths may affect water supplies and demand throughout the system, and can then assess the value of various coping strategies for mitigating the expected impacts. This assessment is not done at the scale of individual water systems, but rather at the scale of four South Platte sub-regions (Northern, Central, Southern, and Downstream). This is shown in Figure 1a.[1]

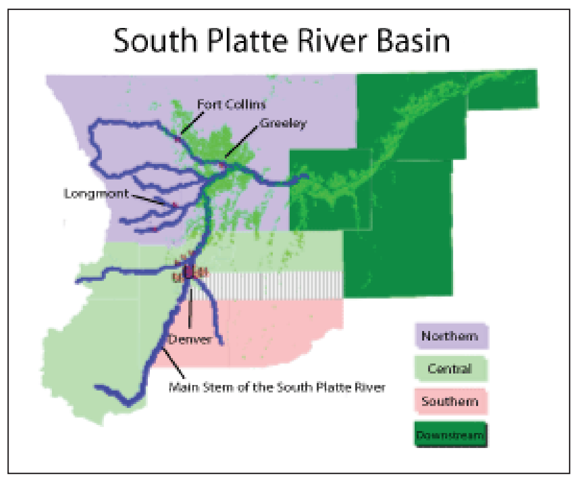


Figure 1a: Map of the South Platte River Basin, showing the four regional divisions used in the SPRAT model.

Water routed through SPRAT derives from historical and recreated inflows and climatic conditions at 28 points throughout

[1] Each sub-region was identified based on its water demand and supply characteristics relative to the rest of the South Platte. The Southern Region includes the rapidly growing and groundwater dependent "south Metro" area; the Central Region includes most of the Denver-Aurora region and water systems reliant on South Platte, Colorado, and Arkansas River surface water supplies; the Northern Region is primarily defined by those agricultural and rapidly expanding municipal areas served by the Colorado-Big Thompson Project; while the Downstream region includes sparsely populated agricultural areas extending to the state line.

the basin spanning 80 years. Supplies consist of five sources: (1) climate-driven runoff (inflows and gains), (2) imported water from adjacent basins (including both the Arkansas and Colorado River basins), (3) return flows, (4) aquifers (not reflected in Figure 2), and (5) reservoir carryover from previous years. The

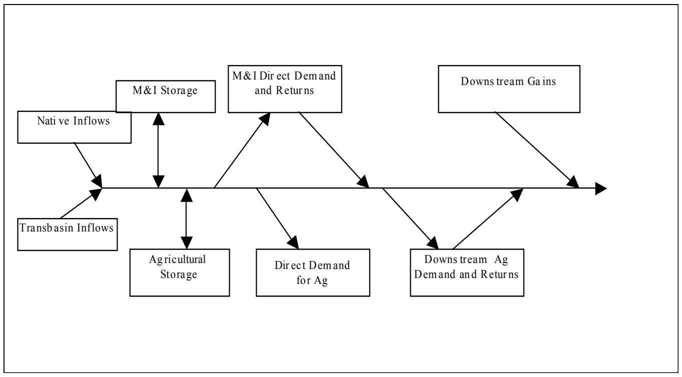


Figure 1b: A simplified illustration of the layout of the SPRAT model over a single stretch of river, within a single region, including the different types of water and water-users accounted for in SPRAT.

management, timing, location, and reliability of each are unique to each sub-region within the Basin and play significant roles in determining each supply's ability to satisfy potential demand. For example water users in the Northern sub-region have access to highly reliable flows available via the federal Colorado Big-Thompson project, whereas users in the Southern sub-region rely predominantly on groundwater from the Denver Basin Aquifer.

SPRAT allocates available supplies to existing demands during each month over the 80 year climate record, consistent with current institutional and legal constraints on water allocation (i.e. prior appropriation). Demands are divided into two sectors: (1) municipal and industrial (M&I) and (2) agricultural (Ag). Municipal and industrial demands (M&I) exist in the Northern, Central and Southern regions; whereas agricultural demands exist in the Northern (both upstream and downstream of M&I demands), Central, and Downstream regions. Regional population totals and per capita use are used to generate "base" level M&I demands. Temperature and precipitation are used to adjust base M&I demands in each period. Ag demands are generated using irrigated acreage and climate adjusted per acre application rates.

Figure 1b presents a simplified illustration of the layout of the model over a single stretch of river, within a single region, including the different types of water and water-users accounted for in SPRAT.

Base demands and infrastructure remain constant throughout a given model run (i.e. series of inflow and climate inputs). Thus, model output provides an estimate of what would happen under the *semi-static* demand and infrastructure conditions, given the dynamic series of climatic inputs in the model. The term semi-static is used because population levels are assumed constant in each model run, however per capita demands are adjusted to reflect variability in temperature and precipitation.

Output from SPRAT is available at every point in the model, during every month over the entire period simulated. This output includes streamflow levels, reservoir contents, diversion amounts and unmet demands. Moreover, the design of the model allows users to track the allocation and flow of each of the different types of water (e.g. return flows, trans-basin imports, etc.) included in the model. Thus, those interested in analyzing the impacts of increased diversions to M&I users on water quality, for example, can track the change in return flows relative to total flows throughout different regions in the model.

**Example Model Results: The Impact of Increased M&I Demands on Irrigated Agriculture**

It is commonly postulated that population growth has, and will, result in the loss of irrigated acreage. One recent report, for example, forecasts the loss of 3.1 million acres of agricultural land across Colorado by 2022 due to increased residential development.[2] Projections of this type are typically based on limited historical data, rather than on a systematic analysis that explicitly links M&I trends to agricultural water availability both spatially and temporally. In contrast, SPRAT allows planners the opportunity to directly model how increased deliveries to M&I users will impact supplies available for irrigated acreage by sub-region and with respect to varying types of climatic events, growth rates, and infrastructure expansions.

As an illustration, consider model runs comparing two scenarios based on historical climatic conditions from the period 1918 to 2002: *Baseline* (current population and infrastructure conditions) and *2030 Population* (projected 2030 population with no policy or infrastructure changes). Model estimates of annual, agricultural, *unmet demands* were prepared under each scenario. These two scenarios allow for the isolation of the effects of increased deliveries to M&I users on the flows available for agricultural users in each sub-region. Results are shown in Figure 1c, which provides predicted changes (*Baseline* to *2030 Population*) in unmet agricultural demands as a percent of total demand over the period of study. Positive (negative) values indicate an increase (decrease) in unmet demands.

Consistent with conventional wisdom, the model predicts increasing M&I demands in the Northern sub-region will reduce

[2] *Losing Ground: Colorado's Vanishing Agricultural Landscape* (Environment Colorado Research and Policy Center, 2006)

flows available for junior irrigators in that area resulting in an increase, on average, of unmet agricultural demands. However, somewhat surprisingly, unmet demands actually are shown to decrease in the Central and Downstream sub-regions. In these two areas irrigated agriculture is primarily located downstream of most M&I demands. Under the *2030 Population* scenario, water which was previously diverted to meet upstream, agricultural demand and excess groundwater pumping is now utilized to meet M&I demands, which results in increased return flows for downstream users in both sub-regions. On average, these return flows reduce unmet demands for irrigators in each of these two sub-regions.

Is this our prediction of the future? Not hardly. These scenarios are admittedly simplistic; for example, the *2030 Population* scenario used here does not account for many of the likely institutional and infrastructure changes that would accompany such growth (e.g., water transfers, reservoir development, etc.). Additional scenarios with varying levels of population growth, policy or infrastructure changes, and simulated climatic conditions could provide a much richer picture of possible future outcomes, helping communities to make more informed choices about vulnerabilities, sensitivities, and appropriate adaptations. SPRAT is designed to facilitate this thinking.

**Future Research**

SPRAT offers stakeholders throughout the South Platte Basin a new tool for exploring possible water futures in a way not possible through other means. Any party interested in exploring additional scenarios is encouraged to contact the Western Water Assessment for a SPRAT demonstration and/or to discuss a potential collaborative project.

*Further information regarding SPRAT is available from Chris Goemans (chris.goemans@colorado.edu).*

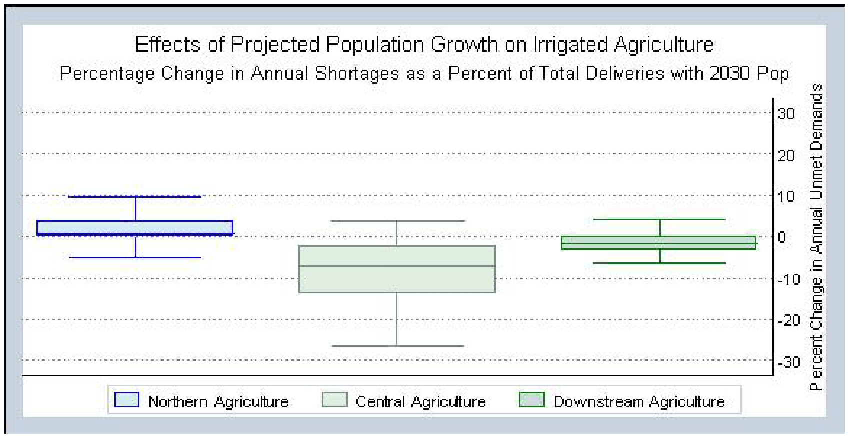


Figure 1c: Chart showing predicted changes for an example model run (Baseline to 2030 Population) in unmet agricultural demands as a percent of total demand over the period of study. Positive (negative) values indicate an increase (decrease) in unmet demands. The boundaries of each "box" identify the 25th and 75th percentiles of the change in unmet demands as a percentage of total agricultural demand in each region. The range between each of the "Whiskers" accounts for approximately 90% of the observed values for each region.

**References:**

Colorado Water Conservation Board, "Statewide Water Supply Initiative." November 2004. http://cwcb.state.co.us/SWSI/swsireport.htm

Dai, T. and J. Labadie, "River Basin Network Model for Integrated Water Quantity/Quality Management," Journal of Water Resources Planning and Management, ASCE, 127(5), pp. 295-305 (Sep/Oct 2001).

Environment Colorado Research and Policy Center, "Losing Ground: Colorado's Vanishing Agricultural Landscape." April 2006. http://www.environmentcolorado.org/envco.asp?id2=23275.

**On the Web**

- For more information about SPRAT, visit their website at: http://wwa.colorado.edu/products/sprat.