Decision Support Simulation for a Water Basin
Purpose of DSS

- Based on systems modeling
- Incorporates all major processes within a system
- Demonstrates effects of seemingly isolated decisions on the entire system
- May show surprising or unanticipated results of management options
DSS in Education

- Gives students a hands-on tool to learn about water resources
- Teaches comprehensive and inter-related concepts while keeping complicated modeling hidden
- Allows students to identify effective management strategies and develop compromise plans
Typical DSS Elements

Flow Rate ➔ Reservoir/Level

This is the data that can be altered on user interfaces
Example of User Interface

Agriculture

NOTE: If you are overriding this generic input, please go to: Agriculture Override

<table>
<thead>
<tr>
<th>Acres</th>
<th>% Acres Using Reclaim</th>
<th>% Acres Retired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>2,500.00 acre</td>
<td>0.00%</td>
</tr>
<tr>
<td>Lettuce</td>
<td>200.00 acre</td>
<td>0.00%</td>
</tr>
<tr>
<td>Cotton</td>
<td>12,100.00 acre</td>
<td>0.00%</td>
</tr>
<tr>
<td>Wheat</td>
<td>4,200.00 acre</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Pre-Retirement Demand: 99.79 kafy
Post-Retirement Demand: 99.79 kafy
Total New Demand: 99.79 kafy
Total Effluent Desired: 0.00 kafy
Total Effluent Used: 0.00 kafy
Agriculture Recharge: 14.37 kafy

Farmer Profit: 2.99 Million$/yr

Total Retirement Costs: $0.00
Total Farmer Income: $0.00

Note: It would not be practical for all agriculture acreage to be connected to the reclaim system because some farms are far away from the water system. For this reason, it is limited to 50%. Also, lettuce is a high water-content food crop and cannot use reclaimed water.
Water Basin DSS

- Regional System approximately size of Tucson
- Limited water supply
- Multiple demand sectors
- Population growth over 25 year simulation
- Presents various ways to make supply meet demand
- Allows observation of multiple options in a short time
- Provides opportunity for cost-benefit analysis
Supply

- **Groundwater**
  - 18.5 million acre-ft aquifer
  - Renewable supply

- **Surface Water**
  - Average streamflow of 200 cfs
  - Minimum downstream flow

- **Reservoir**

- **Imported Water**

- **Tribal Water**
  - May be purchased

- **Reclaimed Water**
  - Can only be used for certain demand

www.cap-az.com

www.wwm.pima.gov
Demand

- Residential
  - Indoor and Outdoor

- Agriculture
  - Alfalfa, Lettuce, Cotton, Wheat

- Environmental
  - In-stream flow requirements

- Turf
  - Private golf courses
  - Public golf courses and parks
  - Schools

- Industrial
Supply Submodels
Residential Submodels

Clotheswasher

Shower
Submodel Interface

**Residential**

<table>
<thead>
<tr>
<th>Category</th>
<th>Indoor Demand</th>
<th>Outdoor Demand</th>
<th>Residential Demand</th>
<th>Residential New Demand</th>
<th>Rainwater, Gray Water, Effluent</th>
<th>Irrigation Recharge</th>
<th>Return to WWTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Older Homes with Fixture Retrofits</td>
<td>53.44 kafy</td>
<td>26.17 kafy</td>
<td>79.61 kafy</td>
<td>79.52 kafy</td>
<td>0.06 kafy</td>
<td>1.12 kafy</td>
<td>53.44 kafy</td>
</tr>
<tr>
<td>% Homes with Frontloading washer</td>
<td>71 gpcd</td>
<td>35 gpcd</td>
<td>165 gpcd</td>
<td>165 gpcd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Homes with Drip Irrigation (vs Turf)</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Households Harvesting Rainwater</td>
<td>21%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Homes with Pools</td>
<td>0.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% New Homes with Reclaim Connection</td>
<td>0.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% New Homes with Gray Water Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note that if changing % with reclaim does not change 'Rainwater, Gray water, effluent', this means that ag and turf demand have exhausted the reclaim supply.**

**Aquifer Volume**

- Total Retrofit Cost includes the costs of fixture retrofits and the extra cost of purchasing retrofit tools as opposed to toploaders.
Goals and Objectives

Today: Understand Concepts
- Demand by sector
- Consumptive use
- Reclaimed water
- Surface – Groundwater Interactions
- Effects of population growth
- Conservation options
- Environmental effects
Goals and Objectives

- Next time: The Big Picture
  - Different management alternatives and their effects on the system
  - Combine and negotiate options to create the best possible outcome
  - Enhanced supply and treatment options
Big Picture

Day 1&2 – Explore basic model options:

Introductory Questions:
- Turf
- Residential
- Population
- Agriculture
- Water Budget

Control Case Studies – if time

Day 3 – Try to simulate your city

Customization Challenges

Control case studies
- Water supply
- Climate variability

Day 4 – Conflict resolution exercise – role play with major water user stakeholders

Farmer
Developer
City Manager
Conservationist

Goal: Satisfy everyone's water needs
Important Concepts

- **Consumptive Use:**
  - Water that is not returned to the system through recharge or the WWTP
  - \[=\text{Total Demand} - \text{Recharge} - \text{Return to WWTP}\]
  - Generally indoor use is non-consumptive and outdoor use (irrigation) is highly consumptive.

- **Conservation Options:**
  - Fixture retrofits, frontloaders, drip irrigation, rainwater harvesting
Streamflow Processes

- Upstream and Downstream Reach refer to location *Upstream* is streamflow before it gets to the city. *Downstream* is streamflow in the river after the city has taken water from it and released effluent to it.

- Losing and Gaining Reach refer to relationship with the aquifer. *Losing streams* are above the water table, so they lose water to the aquifer (instream recharge). *Gaining streams* are below the water table, so they gain water from the aquifer.
Model Terms

- *Initial year* means before pushing play and *final year* means after pushing play.
- *Default values* are those present when the simulation is reset, or before you change anything.
- *New water* is any water that is not reclaimed water.
- Safe Yield: net Extraction < net Recharge
  This is the goal of Arizona’s AMA’s
Introduction to Powersim
Instructions

- To navigate, use the arrows, Home button, or hyperlinks.
- You can change inputs by using the slider bars or typing values in the boxes below the bars. On the control pages, you simply click the radio buttons or enter inputs.
- You may find it useful to change variables without running the simulation to see direct initial year differences between the results from default values and from the changed values.
- The play button runs the simulation, the play/pause button progresses one year with each click, and the rewind button resets the simulation to the initial year. Each time you reset the simulation, the values return to default.
Inputs and Outputs

- Basic input pages include Agriculture, Turf, Residential, and Population.
- Outputs are found on each input page as well as the main result page, the Water Budget.
- Advanced input pages are found within the Controls.
- Additional results can be found on Supply Costs, Riparian Area, Environmental Economics.
Interpreting Results

- This model displays results both numerically and graphically.
- One way to see results is to look at a numerical value with the default inputs and compare it to the value with your inputs.
- However, sometimes the most important results are best explained through graphs.
- Each input page has two graphs on it; Streamflow and Aquifer Volume. There are also a few other graphs throughout the model. The following page shows you how to read some of these graphs.
Downstream flow will generally be lower than upstream flow, because the region removes water from the stream for use, and only a portion is returned from the WWTP and some water also recharges to the aquifer. If upstream flow falls below downstream flow, this means that the reach has become ‘losing.’ A good goal is to maintain a healthy downstream flow.

The aquifer volume will decline throughout the simulation in response to overdraft (extraction that exceeds total recharge). A good goal is to try to keep it level.
This graph shows demand trends influenced primarily by the population growth rate. Observe the slope of these trends, and compare it to the slopes following a change in the growth rate. Generally the higher the growth rate, the steeper the trend, and thus the greater demand.
Safe Yield

An example of a region meeting safe yield. Extraction does not exceed total recharge, also known as renewable groundwater. The Aquifer Volume graph in this case would actually be slowly rising.