Exploratory Modeling and Decision Support

Patricia Gober

September 15 2017

Decision Center for a Desert City

- NSF DMUU Initiative
- Reframe climate change question to focus on decision making
- Create “what-if” scenarios of the future under policy change
- Boundary organization
- Stakeholder engagement and social learning

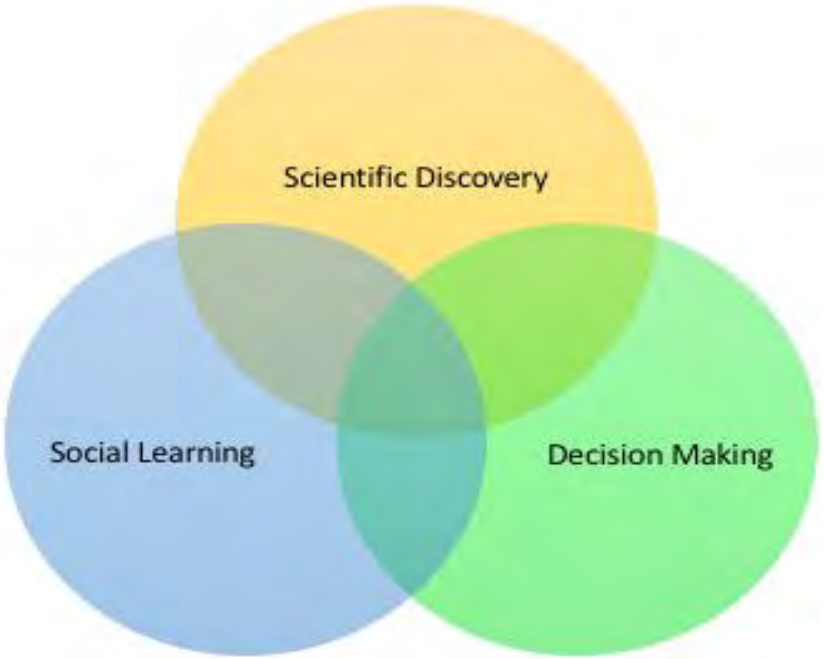
Problems of Deep Uncertainty

- Parties cannot agree upon:
  - The fundamental driving forces that will shape the future and/or the models that describe them
  - The probability distributions used to represent uncertainty and key variables and parameters
  - How to value alternative outcomes

New Questions for Problems of Deep Uncertainty

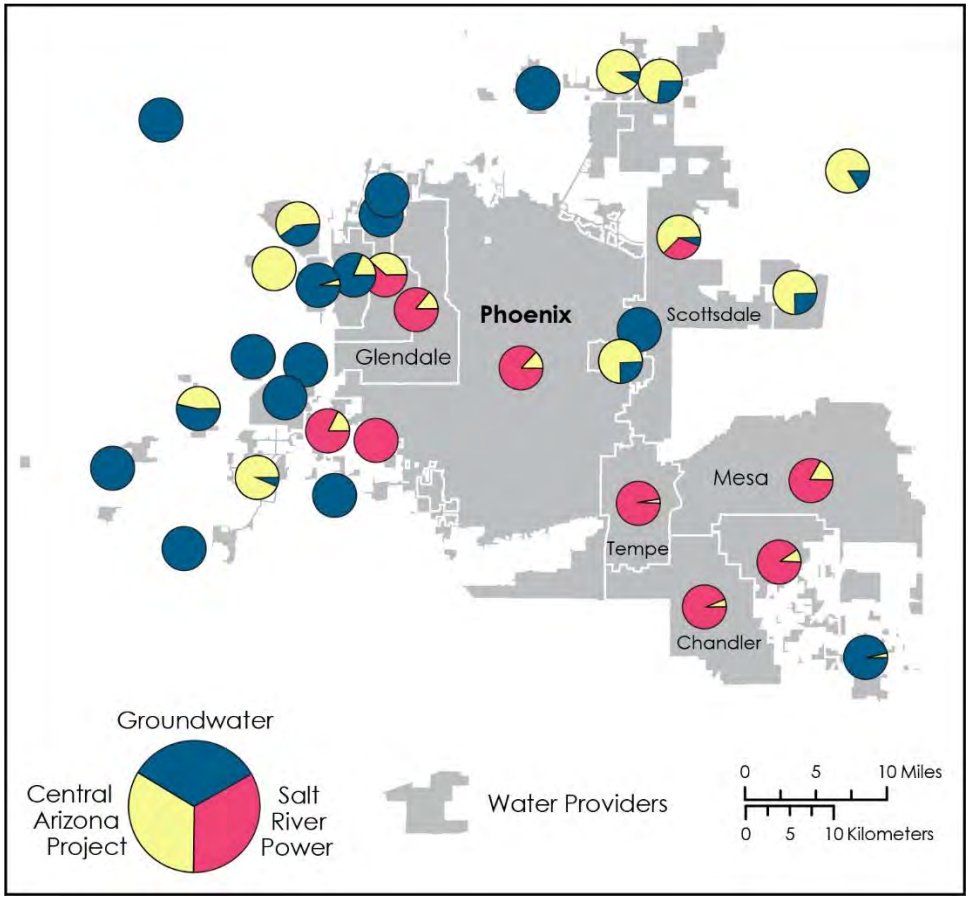
- What kind of future do we want and what decisions do we need to make to get there?
- How to we avoid regrettable outcomes?
- What are the consequences of particular decisions in a complex system?
- What policies work best across a range of climate futures?
- What are the costs of delaying decisions?
- What are the tradeoffs between these costs and the risk of making expenditures that are not necessary

Purposes of IWRM Modelling

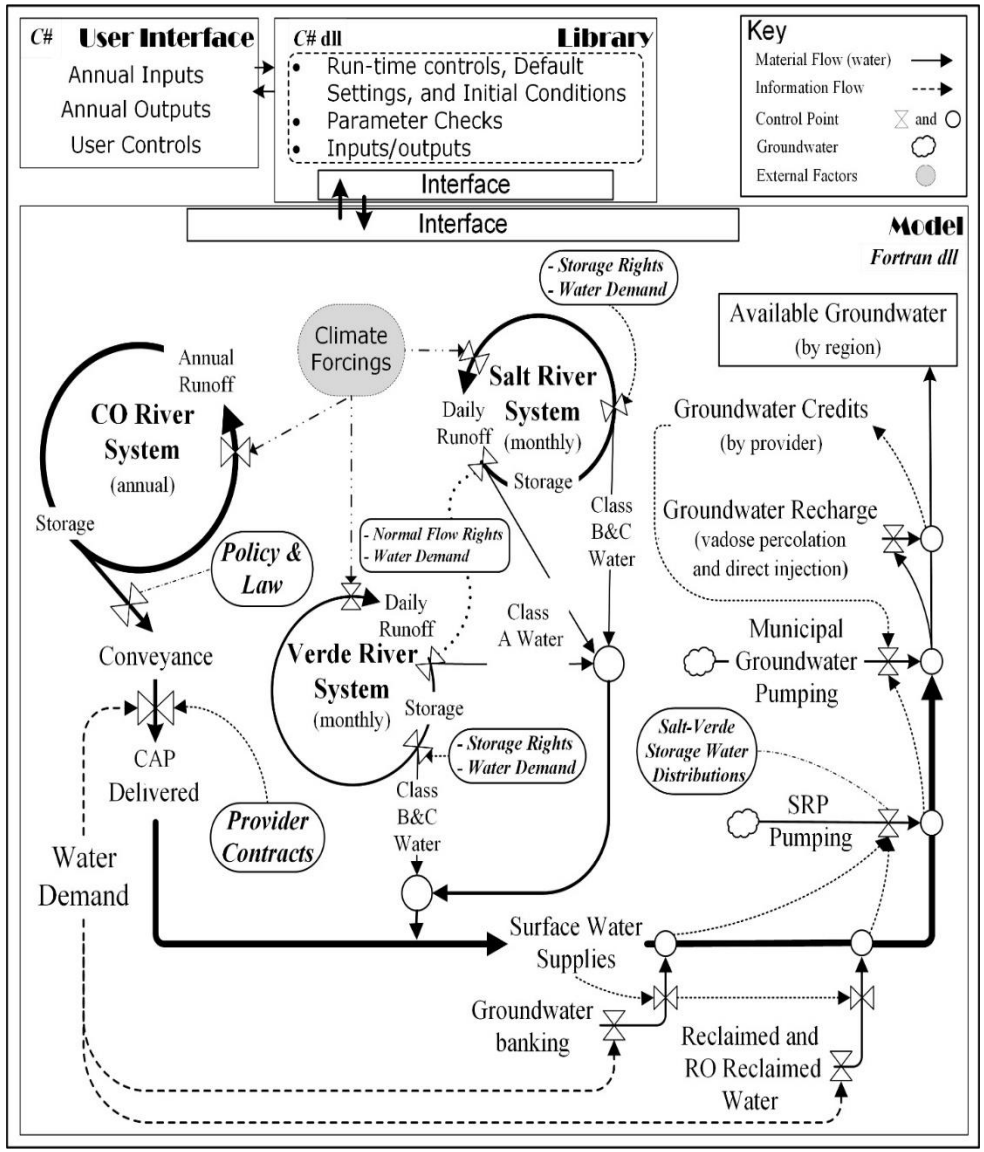


Phoenix has a large hydraulic reach.

Fragmented Governance



WaterSim 5


C# User Interface
Annual Inputs
Annual Outputs
User Controls
C# dll Library
• Run-time controls, Default Settings, and Initial Conditions
• Parameter Checks
• Inputs/outputs
Interface
Interface
Key
Material Flow (water)
Information Flow
Control Point and
Groundwater
External Factors
Model
Fortran dll
- Storage Rights
- Water Demand
Available Groundwater (by region)
Climate Forcings
Annual Runoff
CO River System (annual)
Storage
Salt River System (monthly)
Daily Runoff
Storage
Groundwater Credits (by provider)
Groundwater Recharge (vadose percolation and direct injection)
Class B&C Water
- Normal Flow Rights
- Water Demand
Policy & Law
Daily Runoff
Class A Water
Verde River System (monthly)
Storage
Municipal Groundwater Pumping
Conveyance
CAP Delivered
- Storage Rights
- Water Demand
Salt-Verde Storage Water Distributions
Class B&C Water
SRP Pumping
Provider Contracts
Water Demand
Surface Water Supplies
Groundwater banking
Reclaimed and RO Reclaimed Water

Scientific Discovery

Sustainable Cities and Society 27 (2016) 497–504

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Urban adaptation to mega-drought: Anticipatory water modeling, policy, and planning for the urban Southwest

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ARTICLE INFO

Article history:
Received 4 February 2016
Received in revised form 27 April 2016
Accepted 3 May 2016
Available online 22 May 2016

Keywords:
Decision making under uncertainty (DMUU)
Mega-drought
Scenario planning
Water resources management
Sustainable urban development
WaterSim 5

ABSTRACT

This paper uses 'Medieval' drought conditions from the 12th Century to simulate the implications of severe and persistent drought for the future of water resource management in metropolitan Phoenix, one of the largest and fastest growing urban areas in the southwestern USA. WaterSim 5, an anticipatory water policy and planning model, was used to explore groundwater sustainability outcomes for mega-drought conditions across a range of policies, including population growth management, water conservation, water banking, direct reuse of RO reclaimed water, and water augmentation. Results revealed that business-as-usual population growth, per capita use trends, and management strategies are not sustainable over the long term, even without mega-drought conditions as years of available groundwater supply decline over the simulation period from 2000 to 2060. Adding mega-drought increases the decline in aquifer level and increases the variability in flows and uncertainty about future groundwater supplies. Simulations that combine drought management policies return the region to levels that are more sustainable. Results demonstrate the value of long-term planning and policy analysis for anticipating and adapting to environmental and societal change. Similar anticipatory exercises can be used to assess different suites of drought management policies in other cities facing uncertainty about future conditions.

1. Introduction

Climate change is expected to increase the frequency, intensity, and duration of drought in the southwestern United States in coming decades, and questions are being raised about the sustainability of the region's water resources (Cook, Ault, & Smerdon, 2015). General Circulation Models (GCMs) have been used as the basis for projecting future climatic and hydrological conditions under varying greenhouse gas concentration scenarios (Vörösmarty, Green, Salisbury, & Lammers, 2000; Kundzewicz et al. 2008; Arnell, 2004). There is, however, low confidence about the severity, seasonality, and spatial patterns of drought conditions and their implications for regional water supply when the GCMs are combined with regional climate and hydrological models (Wilby & Dessai, 2010). Wilby (2005) and Trenberth (2010) have warned that uncertainties associated with the GCMs are unlikely to be resolved in the short-to mid-term future because models vary in the way they treat complex climate processes, and there are trial-and-error effects associated with adding more variables and feedbacks to capture system dynamics.

Water managers need to make decisions about how to adapt to climate change before the scientific uncertainties of climate modeling and hydrological impact assessment are resolved. They face classic decision making under uncertainty (DMUU) conditions where stakeholders disagree about problem definition and the probability distributions that describe critical components of the system (e.g., future streamflow and climate, per capita water use, behavioral response to policy instruments). Traditional predict-and-plan efforts in water resources management using optimization models are ill-suited to DMUU problems (Gober, Kirkwood, Ellis, & Deitrick, 2010; Quay, 2010). DMUU strategies favor scenario building, exploration of a wide range of policy options, the search for robust policies that work well across a range of climate conditions, and efforts to preserve the flexibility to respond when the unexpected occurs (Lempert, Popper, & Bankes, 2003). Such strategies often use exploratory simulation models to

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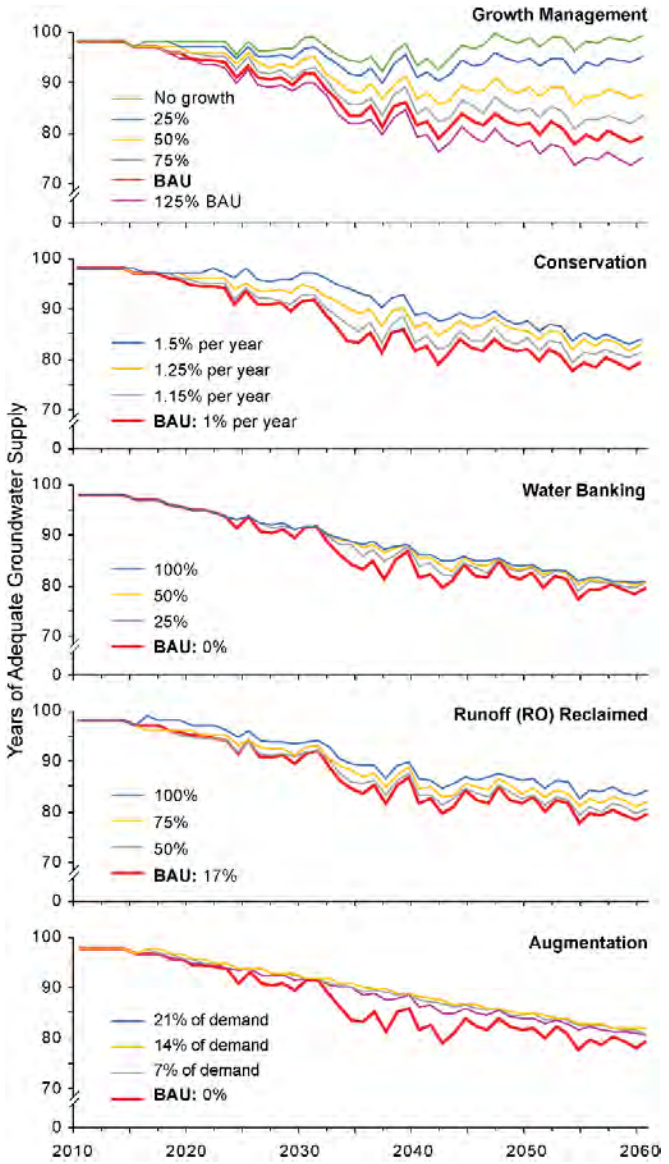
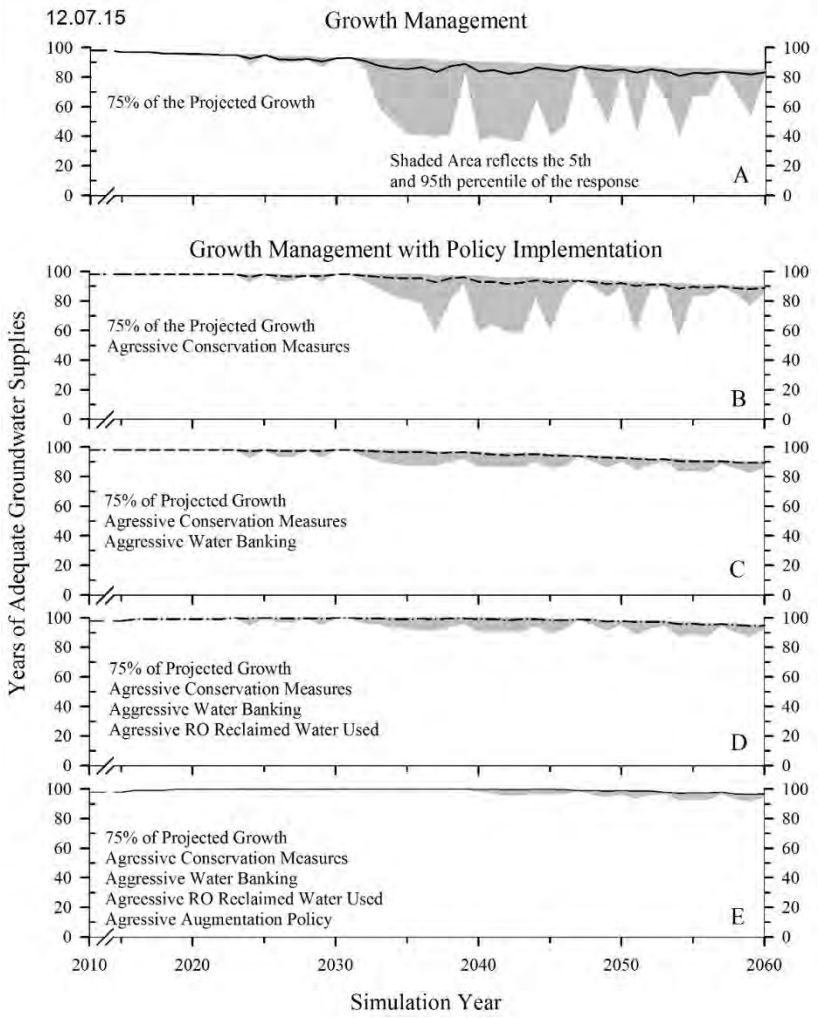
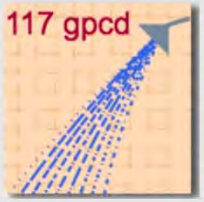
http://dx.doi.org/10.1016/j.scs.2016.05.003
2210-6707/




12.07.15
Growth Management
75% of the Projected Growth
Shaded Area reflects the 5th
and 95th percentile of the response
A
Growth Management with Policy Implementation
75% of the Projected Growth
Agressive Conservation Measures
B
75% of Projected Growth
Agressive Conservation Measures
Aggressive Water Banking
C
75% of Projected Growth
Agressive Conservation Measures
Aggressive Water Banking
Agressive RO Reclaimed Water Used
D
75% of Projected Growth
Agressive Conservation Measures
Aggressive Water Banking
Agressive RO Reclaimed Water Used
Agressive Augmentation Policy
E
Years of Adequate Groundwater Supplies
0
20
40
60
80
100
2010
2020
2030
2040
2050
2060
Simulation Year

Sustainability Indicators



Policy Choices

Wastewater Reclaimed : %

0 | 25 | 50 | 75 | 100 — 19

Farm Water Used by Cities : %

0 | 25 | 50 | 75 | 100 — 30

Water For the CO Delta : % of AZ Share

0 | 25 | 50 | 75 | 100 — 0

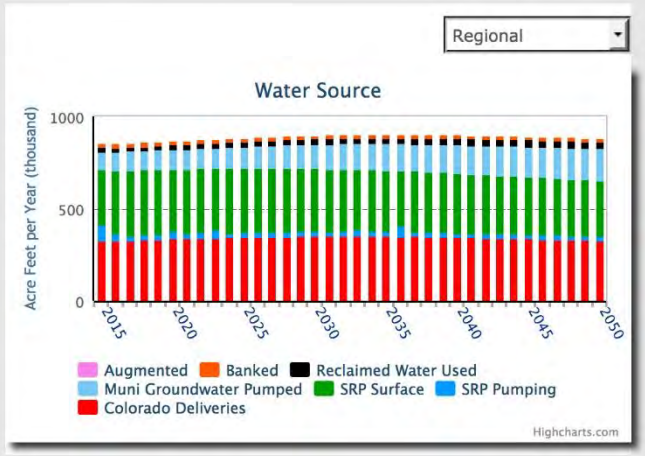
Per Capita Water Use : % of Forecasted

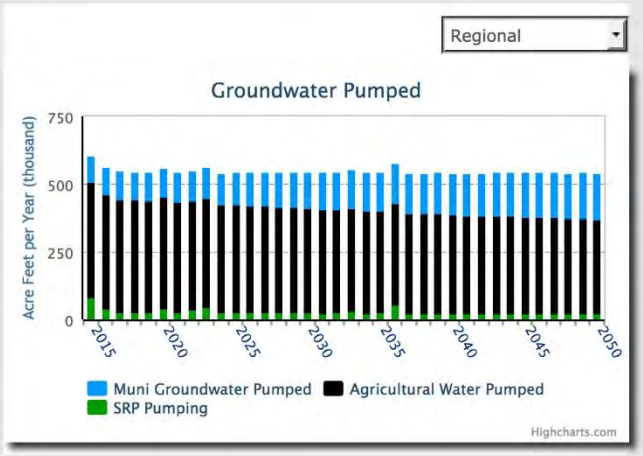
20 | 40 | 60 | 80 | 100 — 100

Population Growth : % of Forecasted

0 | 50 | 100 | 125 | 150 — 100

OUTPUTS: Supply | OUTPUTS: Demand | OUTPUTS: Reservoirs/Rivers | OUTPUTS: Sustainability | INPUTS: Climate/River Flows





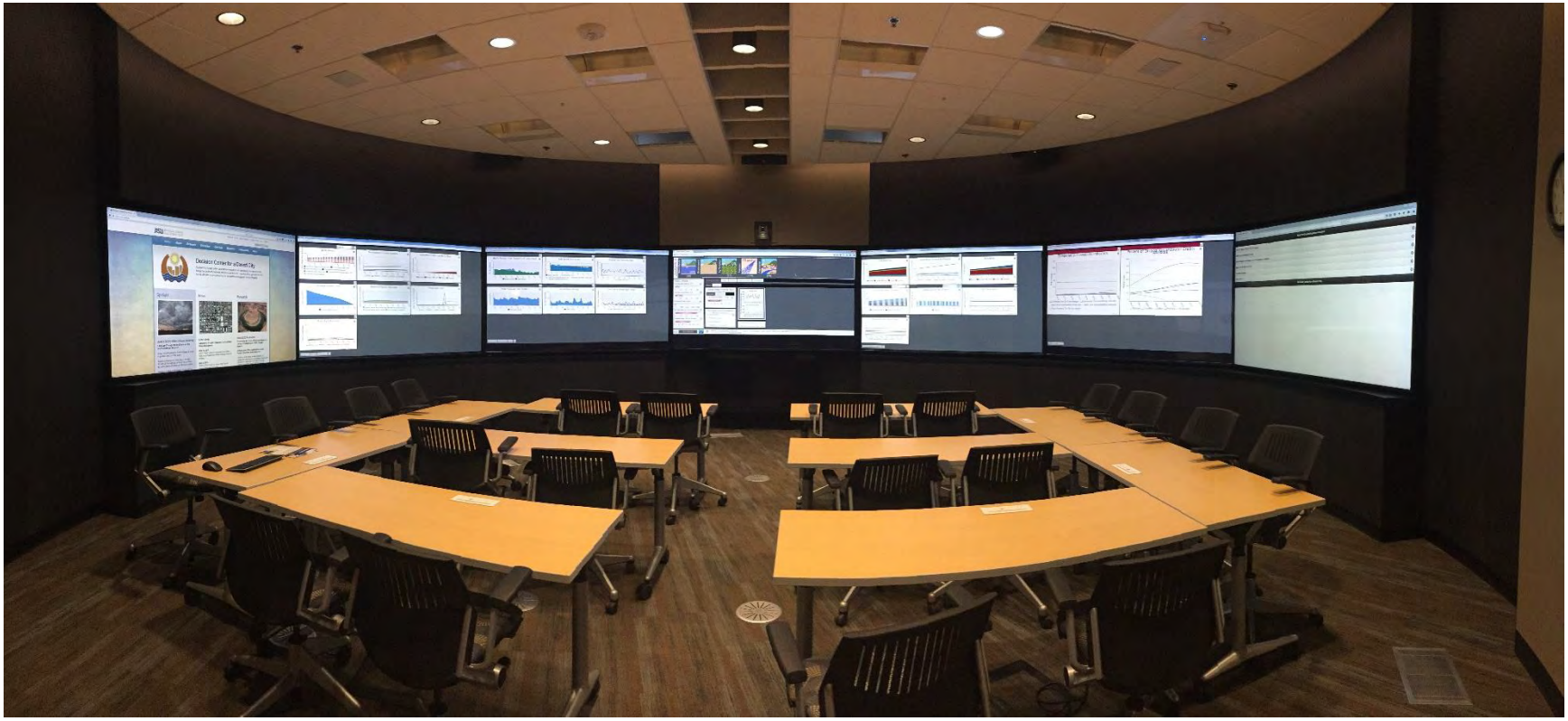
Water Supply | Credits | Regional Aquifer | All

Run Model

ASU Decision Center for a Desert City, Arizona State University

WaterSim Phoenix

WaterSim in Decision Theater



GLOBAL WATER FUTURES

SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

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