Water In Central Arizona

5 million people,[1] 400,000 irrigated acres, a dozen tribes[2] and 8 inches of precip[3]

Ken Seasholes
Manager, Resource Planning & Analysis
Central Arizona Project

[1] 5.8 million, actually
[2] Depending on how you count
[3] Yes, per *year*

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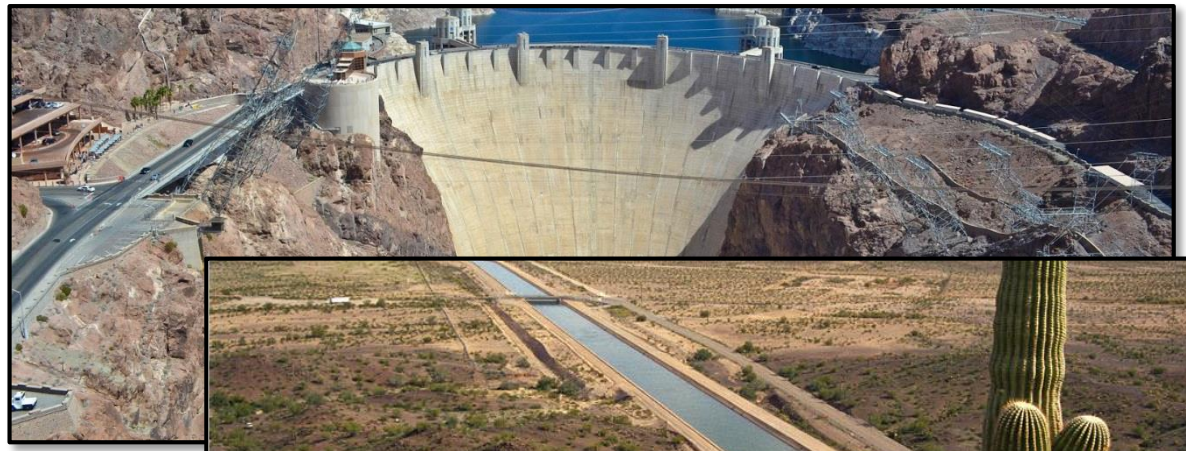

Central Arizona Project

- Diverts ~1.6 MAF of Arizona's Colorado River entitlement
  - 336 mile aqueduct system
  - 15 pumping plants
  - 8 siphons, 3 tunnels
  - 2,900 ft. of lift
  - 2.8 million MWH/yr.
  - Governed by 15-member elected Board
  - ~$350 million annual budget

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Water Supply & Demand

Some of the major factors that affect Arizona water supply, demand and reliability:

- Growth
- Shortage
- Climate Variability
- Socio-Economic Changes
- Agricultural Trends
- Water Storage Preferences
- Policy Changes
- Behavioral Shifts
- ….

"Driving Forces"

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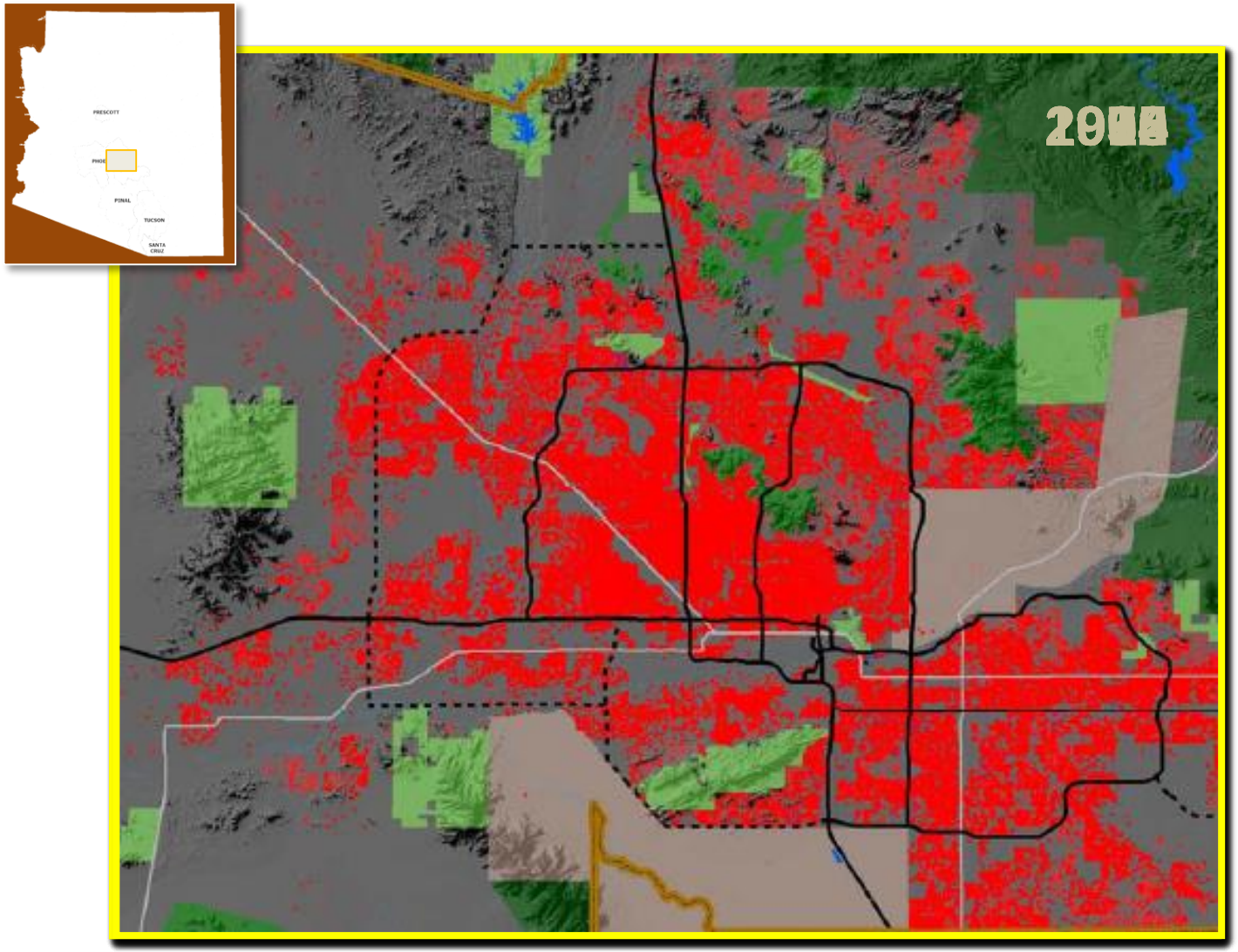
Urban Growth



Source: Maricopa Association of Governments

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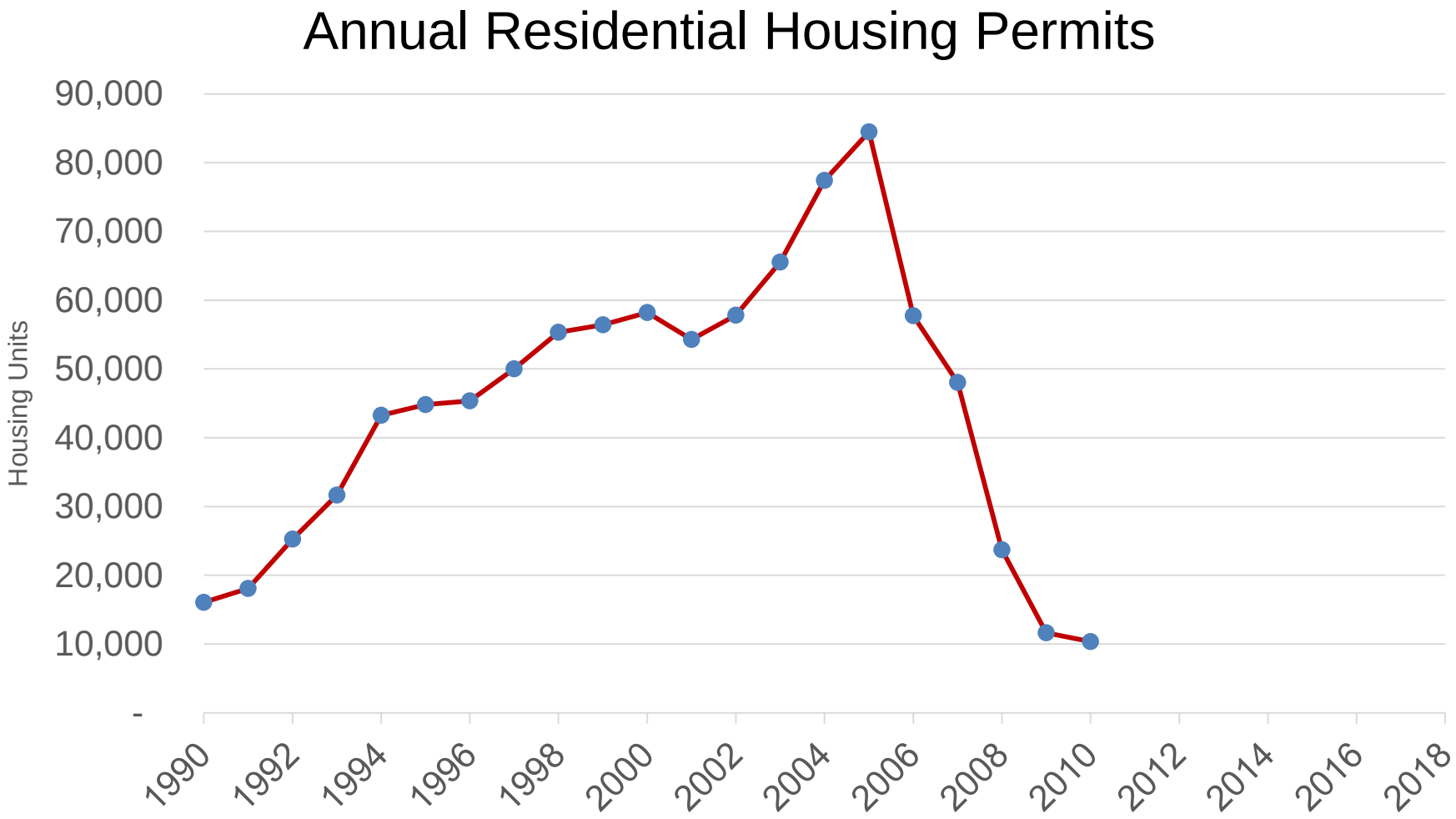
Urban Growth



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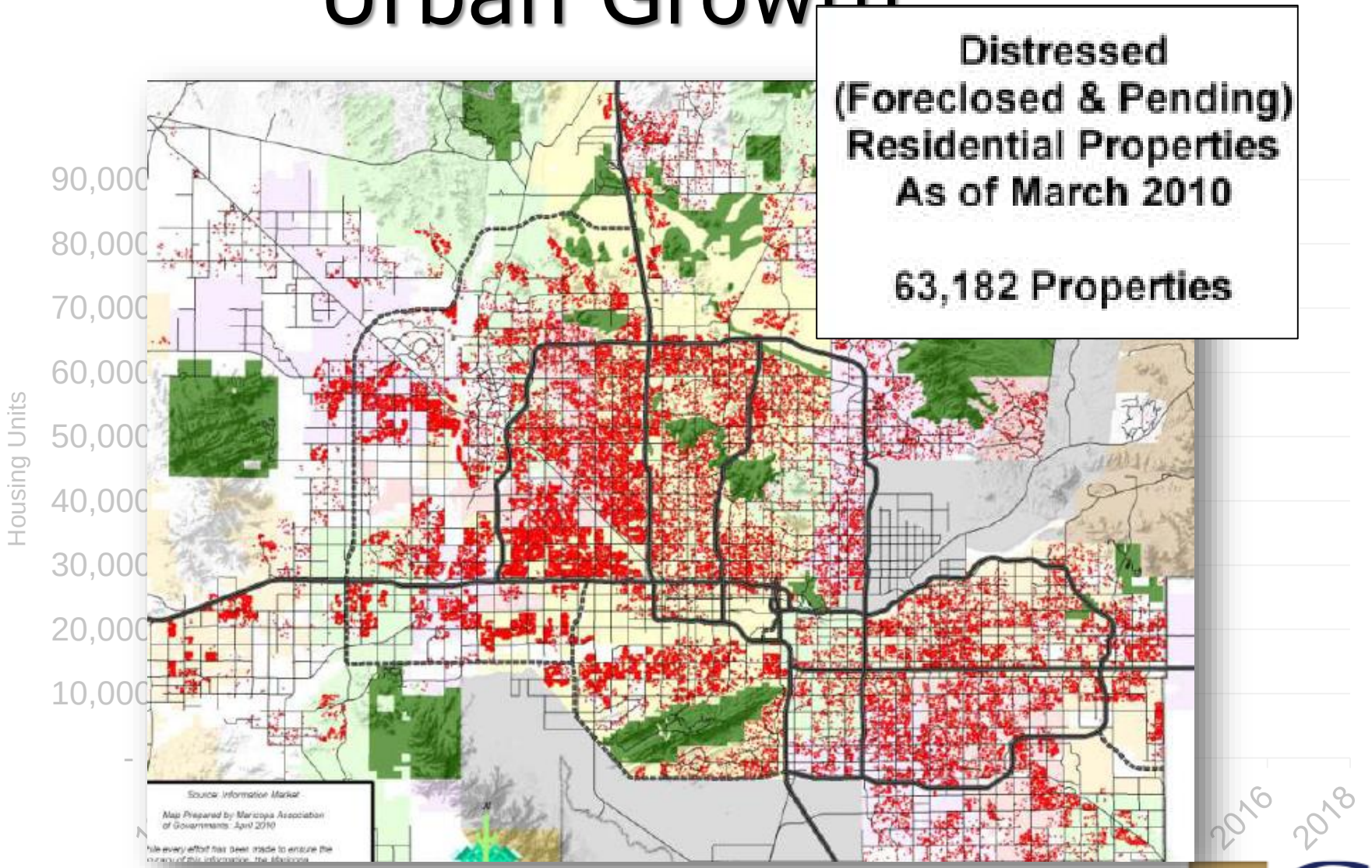
Urban Growth



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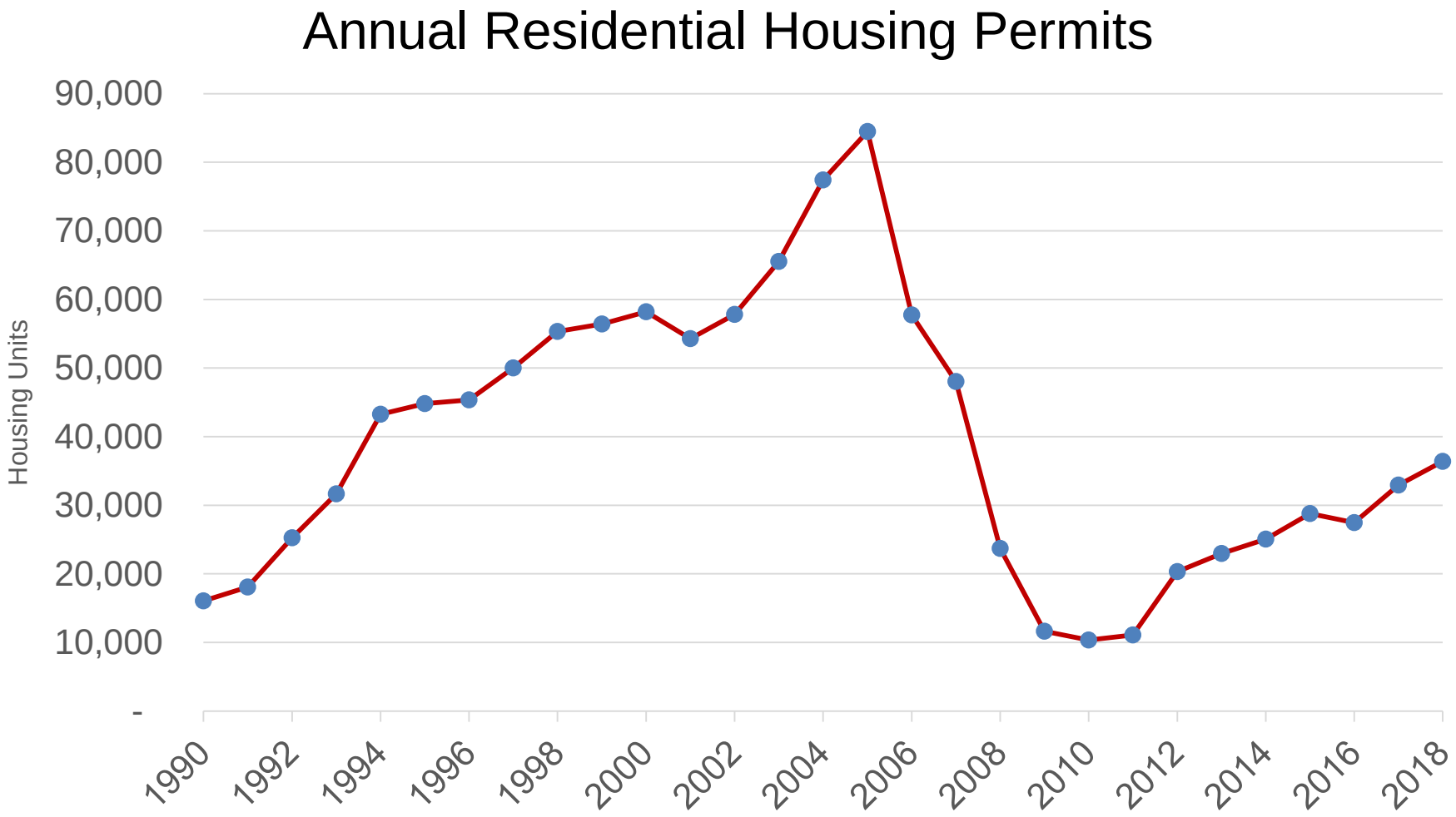
Urban Growth



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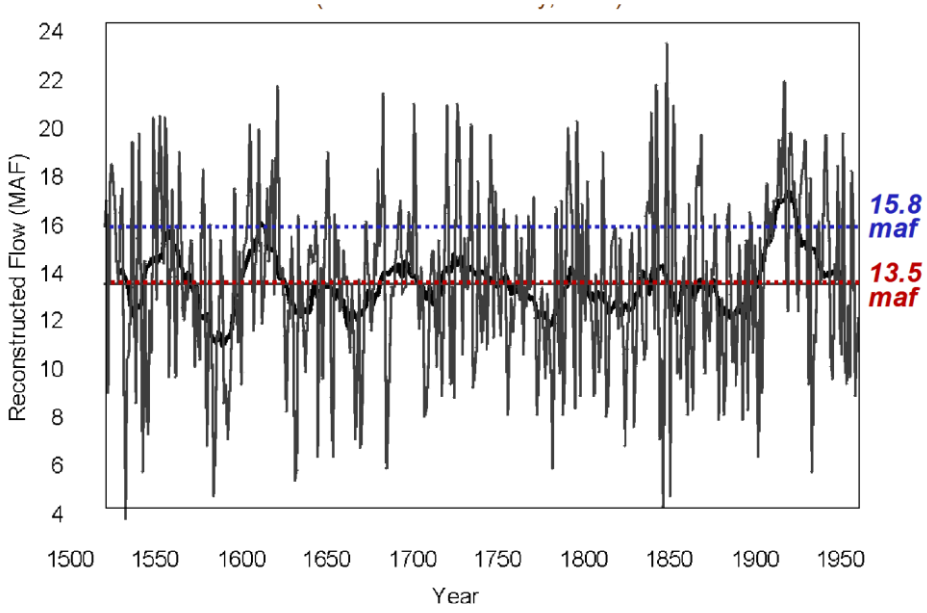
Colorado River

Lower Basin 7.5 MAF

California 4.4 MAF

Arizona 2.8 MAF

Nevada 0.3 MAF



Adapted from ADWR, 1997

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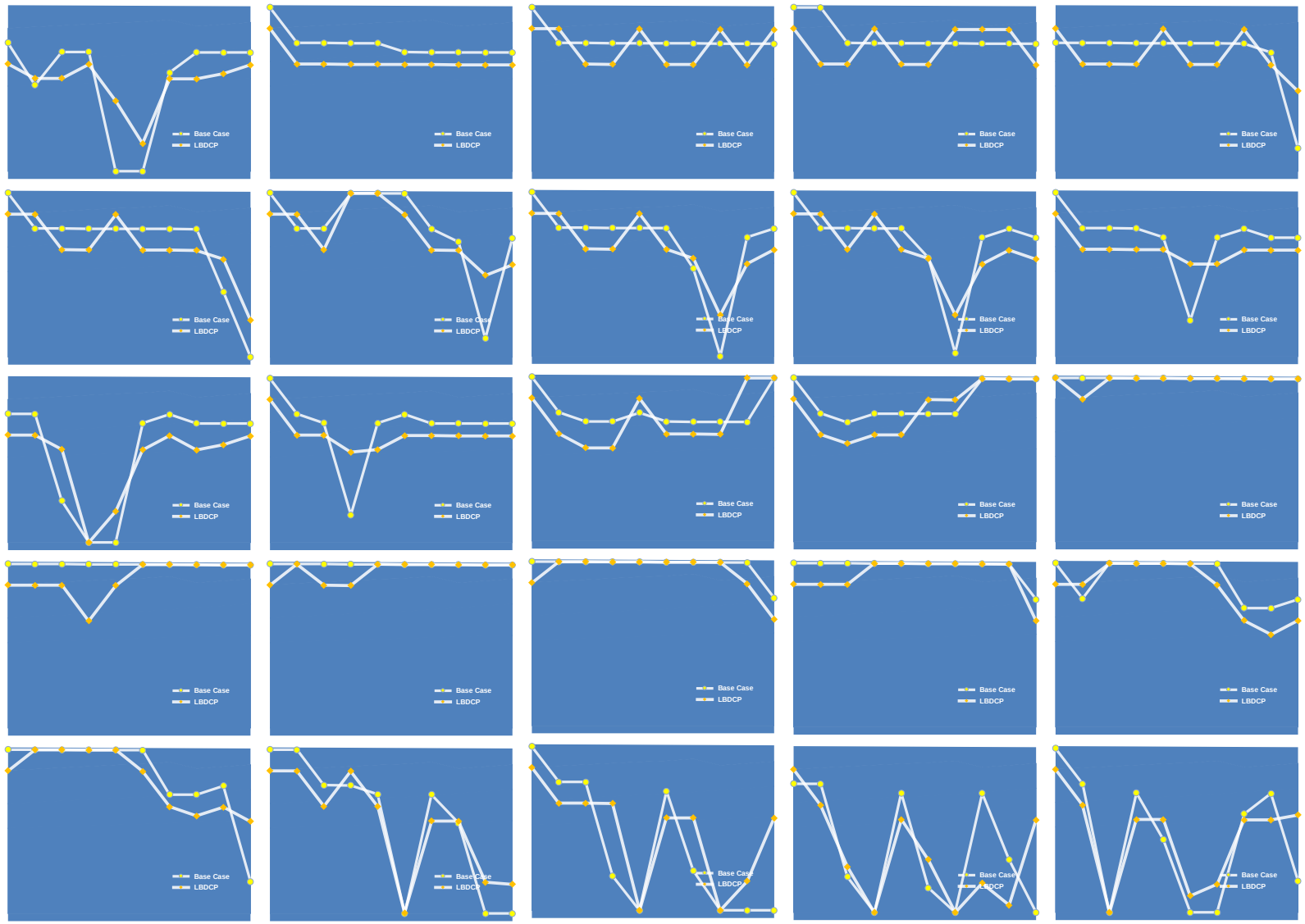
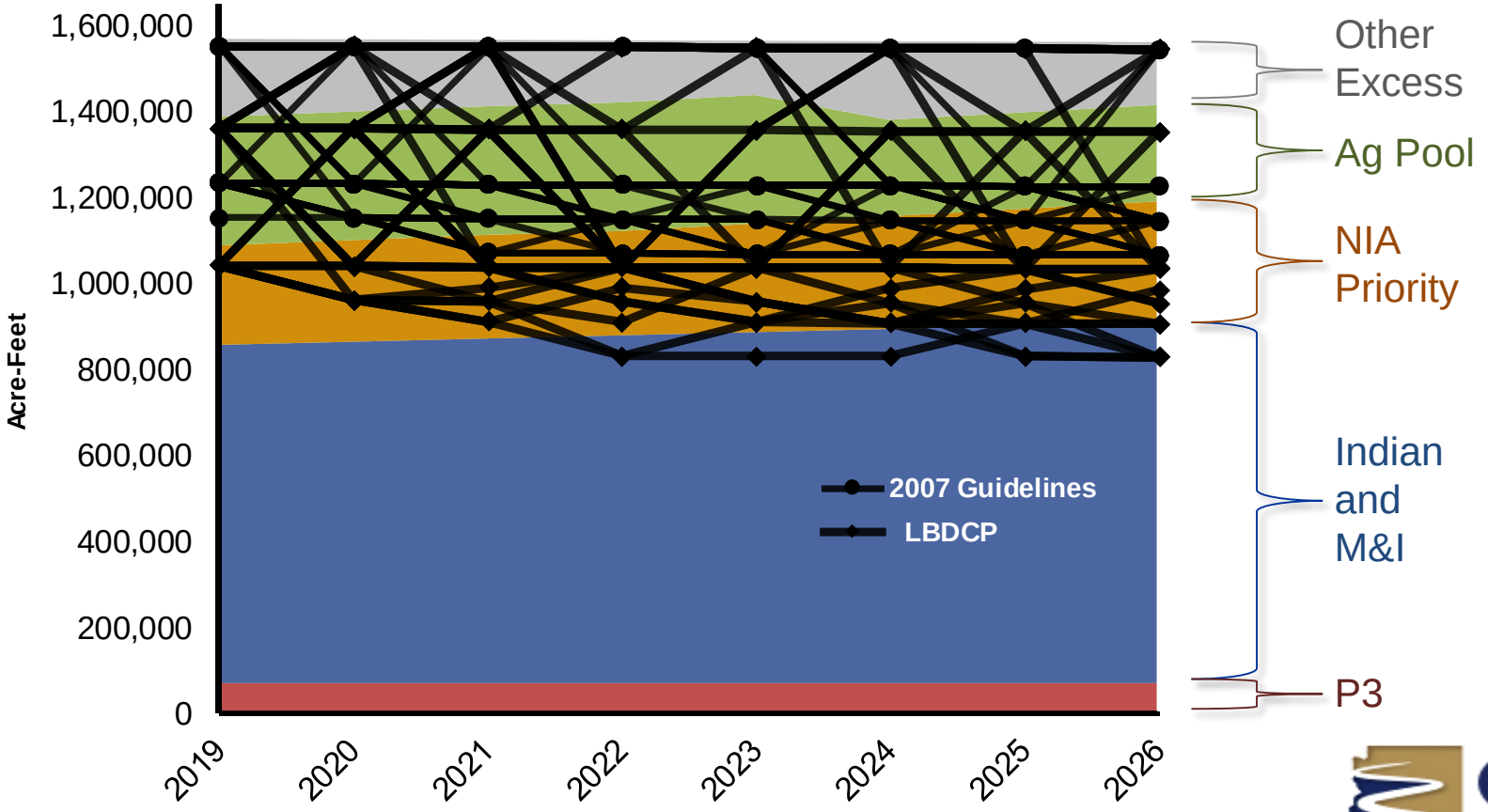
Colorado River Shortage



Colorado River Shortage

Impacts to CAP, by Priority

2007 Guidelines vs. Drought Contingency Plan



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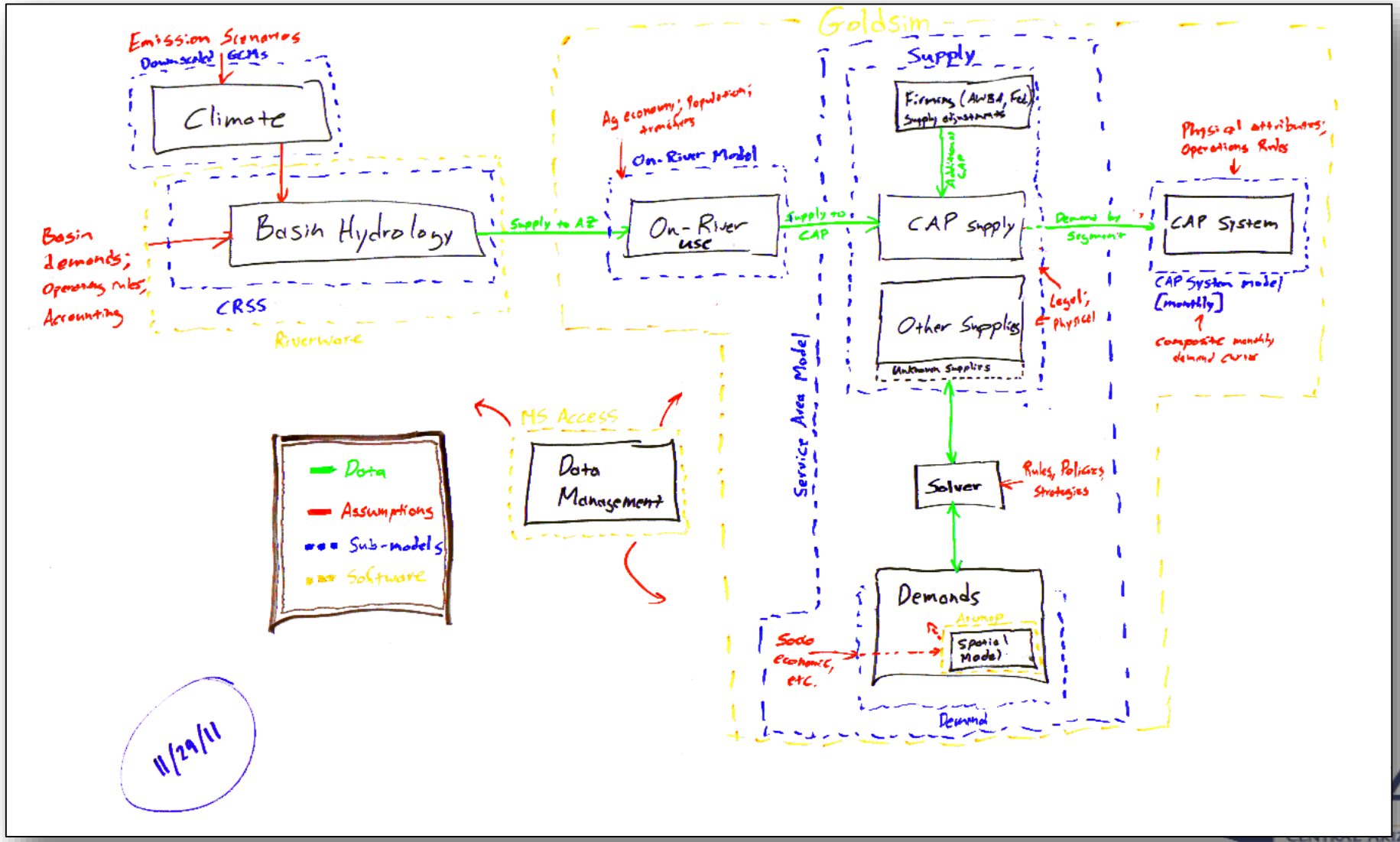
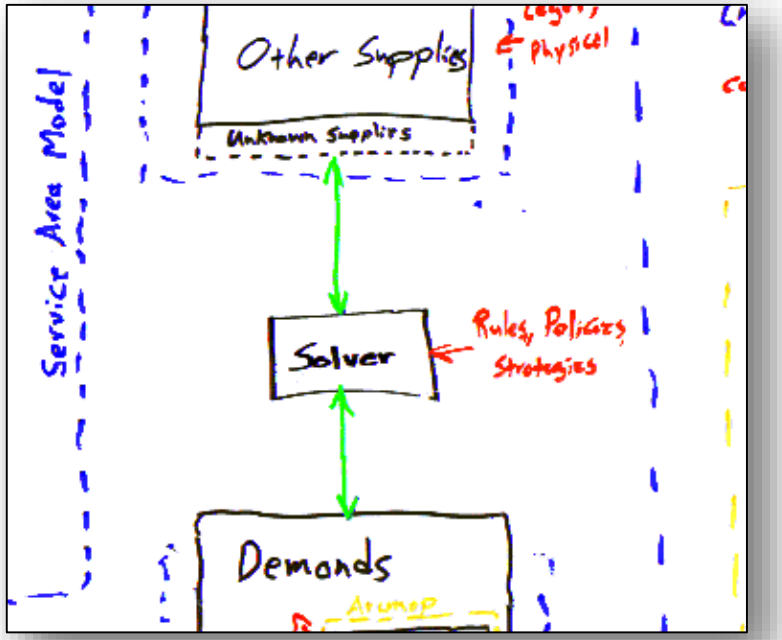
Supply & Demand Modeling



Supply & Demand Modeling

- The complex interplay between supply & demand was ultimately reconciled in a four step process
  - **Calculate** demands
  - **Determine** supplies
  - **Request** supplies
  - **Fulfill** requests



Conceptual Model

Project Demands

Demands: Generally developed without regard to the availability of supply. If a demand is supply defined (e.g., AWBA) the demand is unlimited (i.e., 999).

Time →

Demands

Entity	Demand
Ag 1	500
Muni 1	150
Muni 2	100
AWBA	999

Determine Supplies

Available Supply: Overall physical/legal availability. The order of preference determines the overall sequence used in the "Fulfill Requests" step.

Available Supply

Preference			
	1	SW	50
	2	CAP	507
	3	GW	999

Request Supplies

Supply Requests: Generally the same as the entitlements, but Ag 1's request for CAP less than their allocation.

Supply Requests

Entity	SW	CAP	GW
Ag 1	0	200	999
Muni 1	50	50	999
Muni 2	100	100	999
AWBA	0	999	0

Entitlements: Rights, contracts and policies

Entitlements

Entity	SW	CAP	GW
Ag 1	0	300	999
Muni 1	50	50	999
Muni 2	100	100	999
AWBA	0	999	0

Fulfill Demands

SW: The 50 AF is divided between Muni 1 & 2 on the basis of their entitlements/requests (50 & 100).

SW: Prorate

Muni 1	17
Muni 2	33

CAP: Fill by Priority

Priority			
	1	Muni 1	50
	1	Muni 2	67
	2	Ag 1	200
	3	AWBA	190

CAP: Muni 1 gets its full entitlement; Muni 2 only needs 67 AF to satisfy its remaining demand. Ag gets its request. AWBA gets what is left.

GW: All unsatisfied demand is met with GW (if requested/ entitled).

GW: Fill Remainder

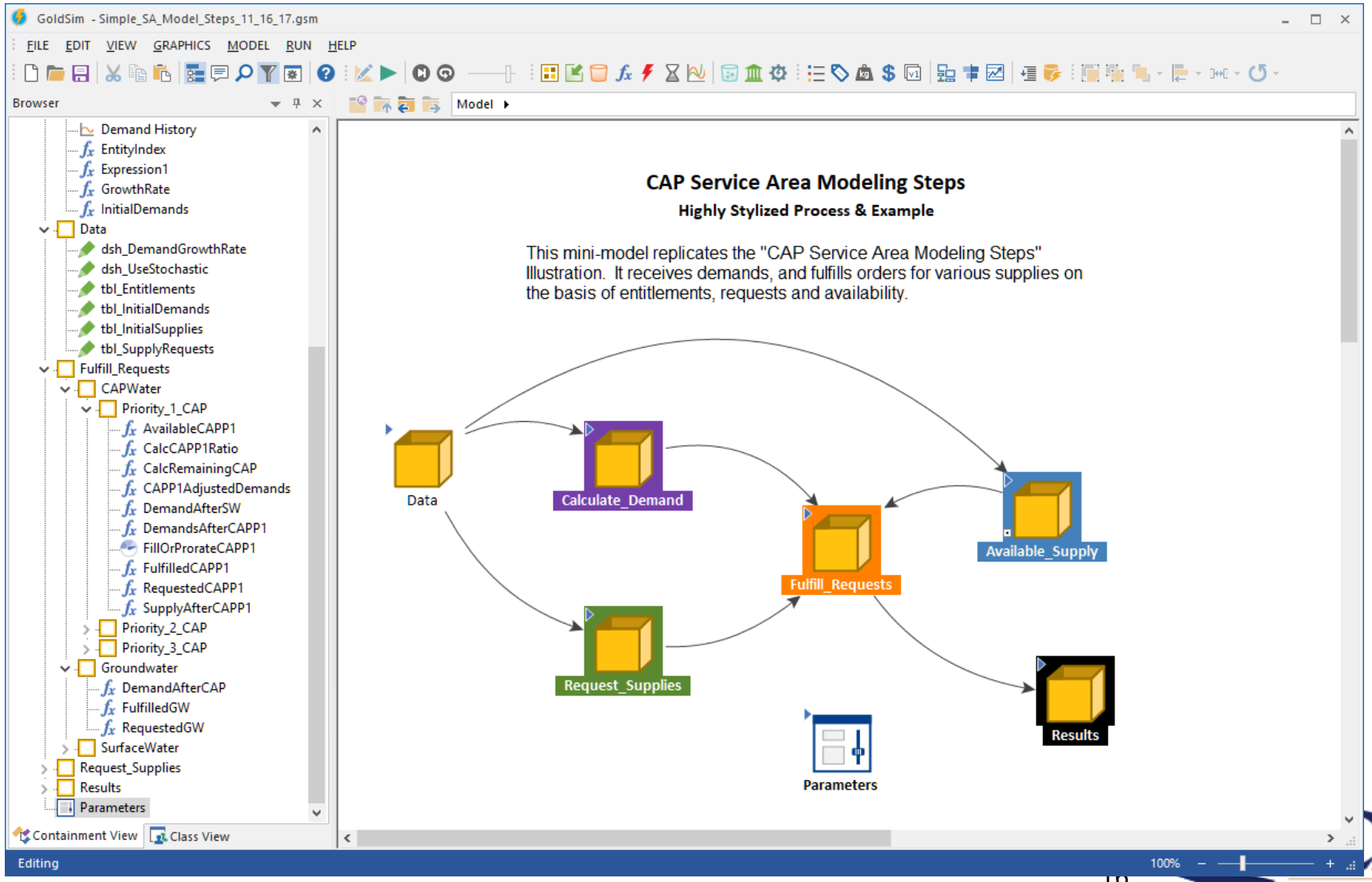
Ag 1 GW	300
Muni 1 GW	83
Muni 2 GW	0

Results

Supplies = Demands

Entity	SW	CAP	GW
Ag 1	0	200	300
Muni 1	17	50	83
Muni 2	33	67	0
AWBA	0	190	0

Simple GS Model



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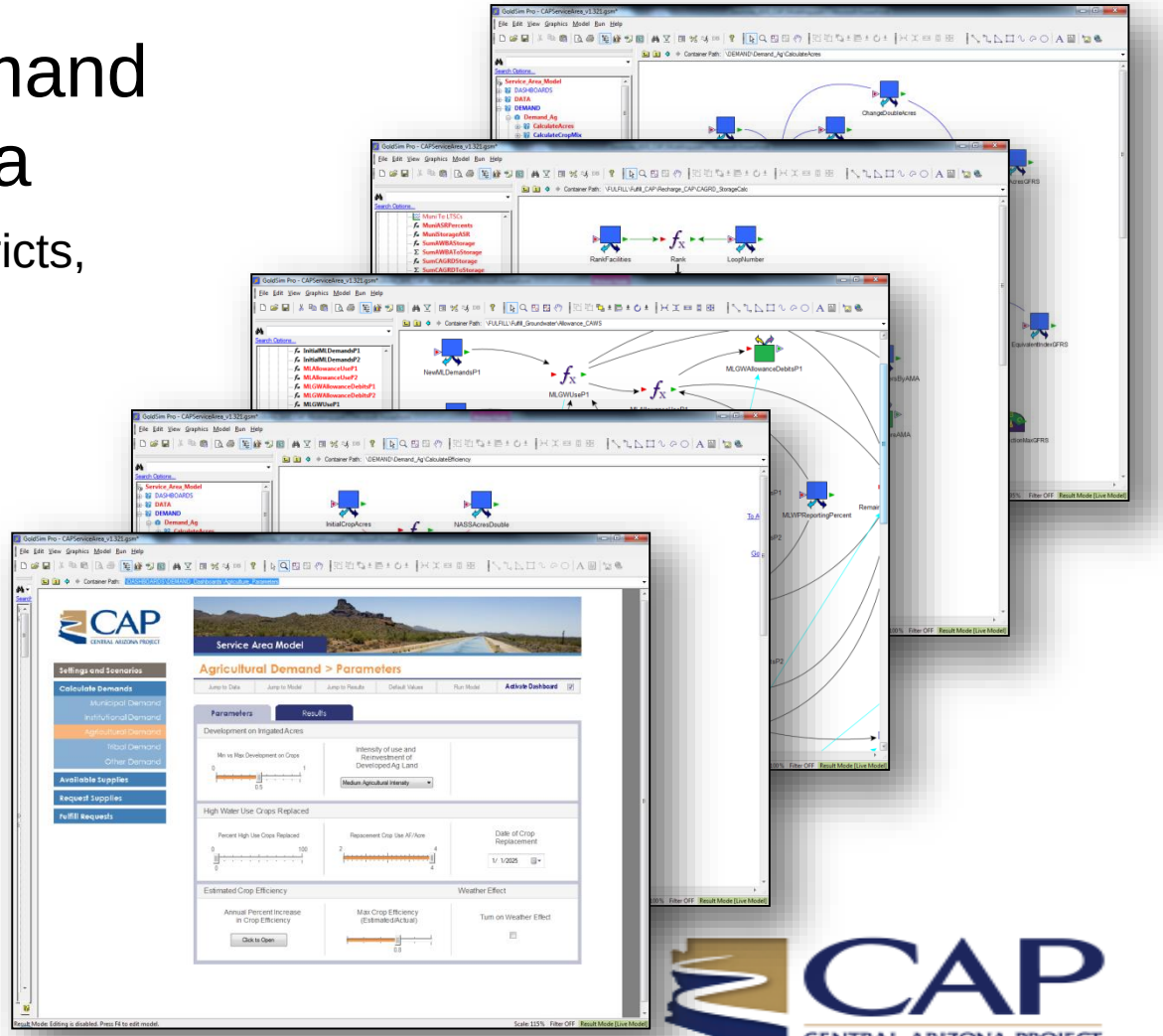
CAP Service Area Model (CAP:SAM)

- Tool for projecting supply and demand in CAP's three county service area
  - 135 entities (municipal providers, irrigation districts, Tribes, AWBA, CAGRD, etc.)
  - 16 water supply types
    - Accounts for complex legal and physical characteristics of users and supplies
    - Designed easily generate "what-if" <u>scenarios</u>



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CAP:SAM Features

- Adjustable rate and spatial pattern of growth
- Variable rates of municipal use and conservation
- Projected agricultural demand, including changes in efficiency, crop types and consumptive use
- Calculated rate of urbanization of active Ag land
- Dynamic distribution of recharge activity
- Tracking of water supply portfolios, including leases, exchanges and long-term storage credits
- Processing of data from Colorado River Simulation System model

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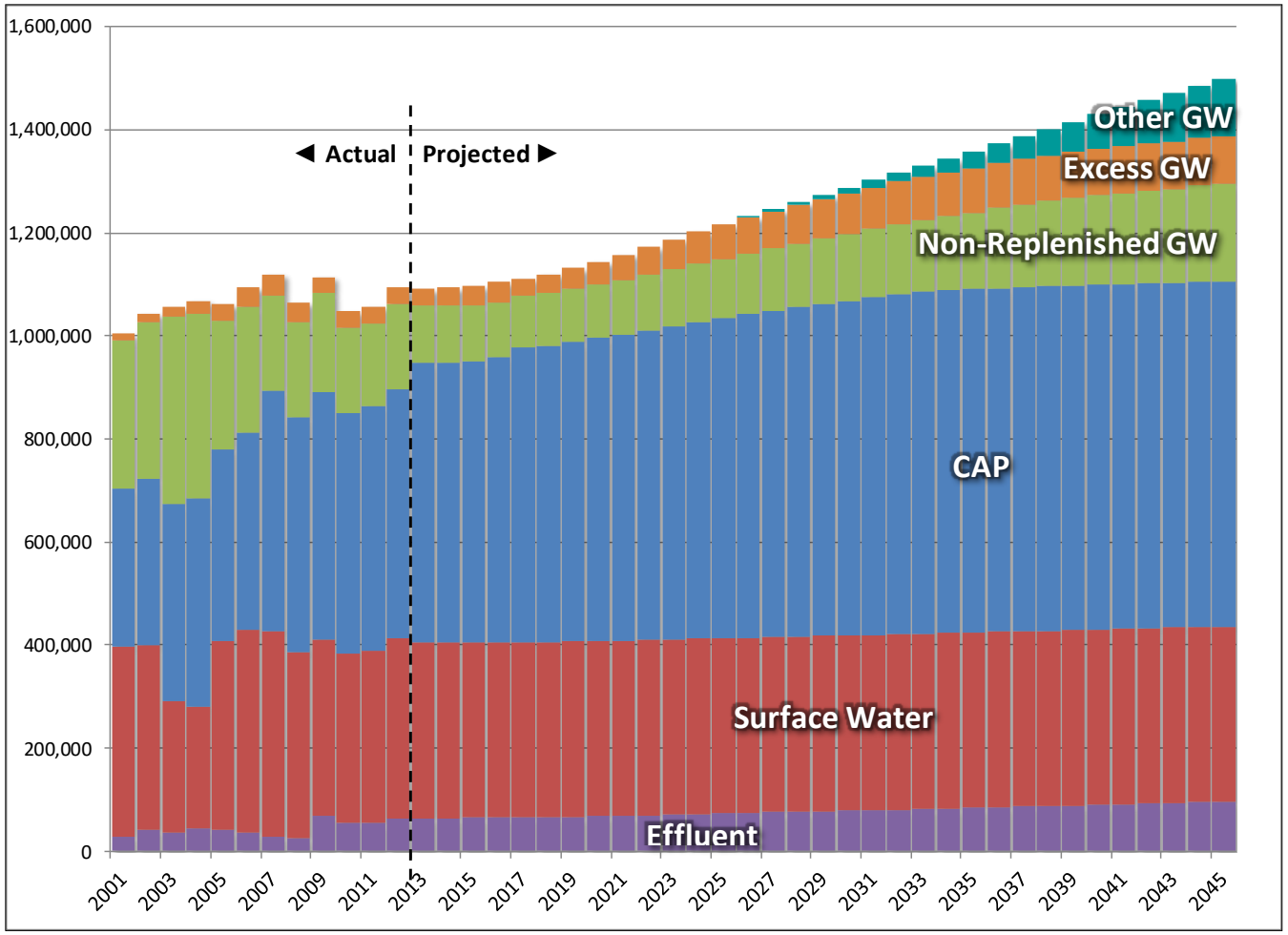
Summaries for Regulatory Submission



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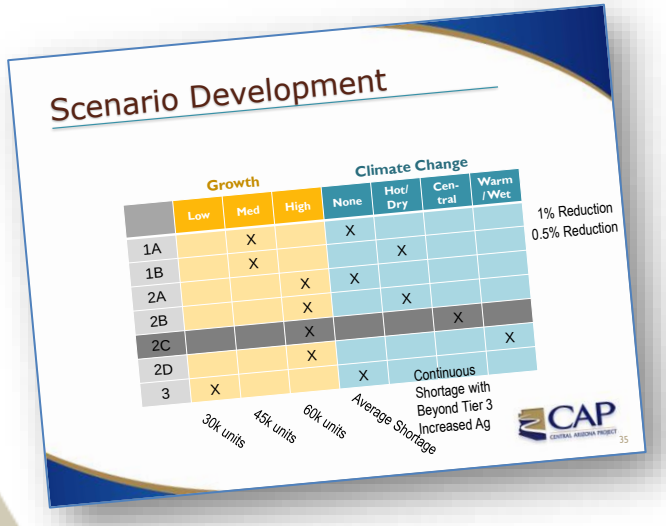
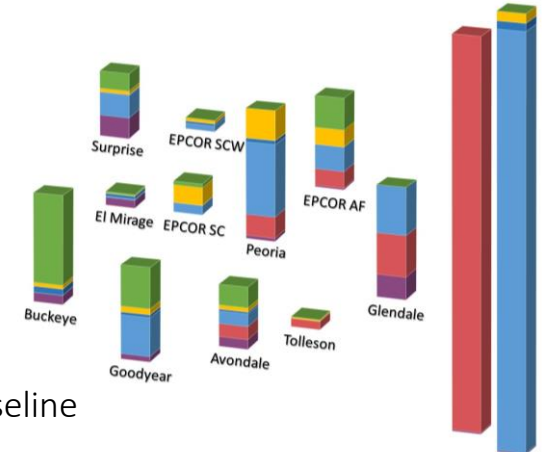
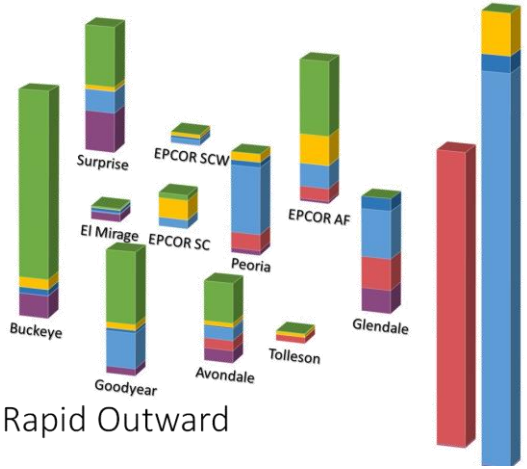
Scenarios for Regional Planning

- Support for Bureau of Reclamation "Basin Studies"
  - Identification of supply & demand "imbalances"
  - Consideration of climate change
  - Integration with regional groundwater flow models





Baseline



Dry, Rapid Outward

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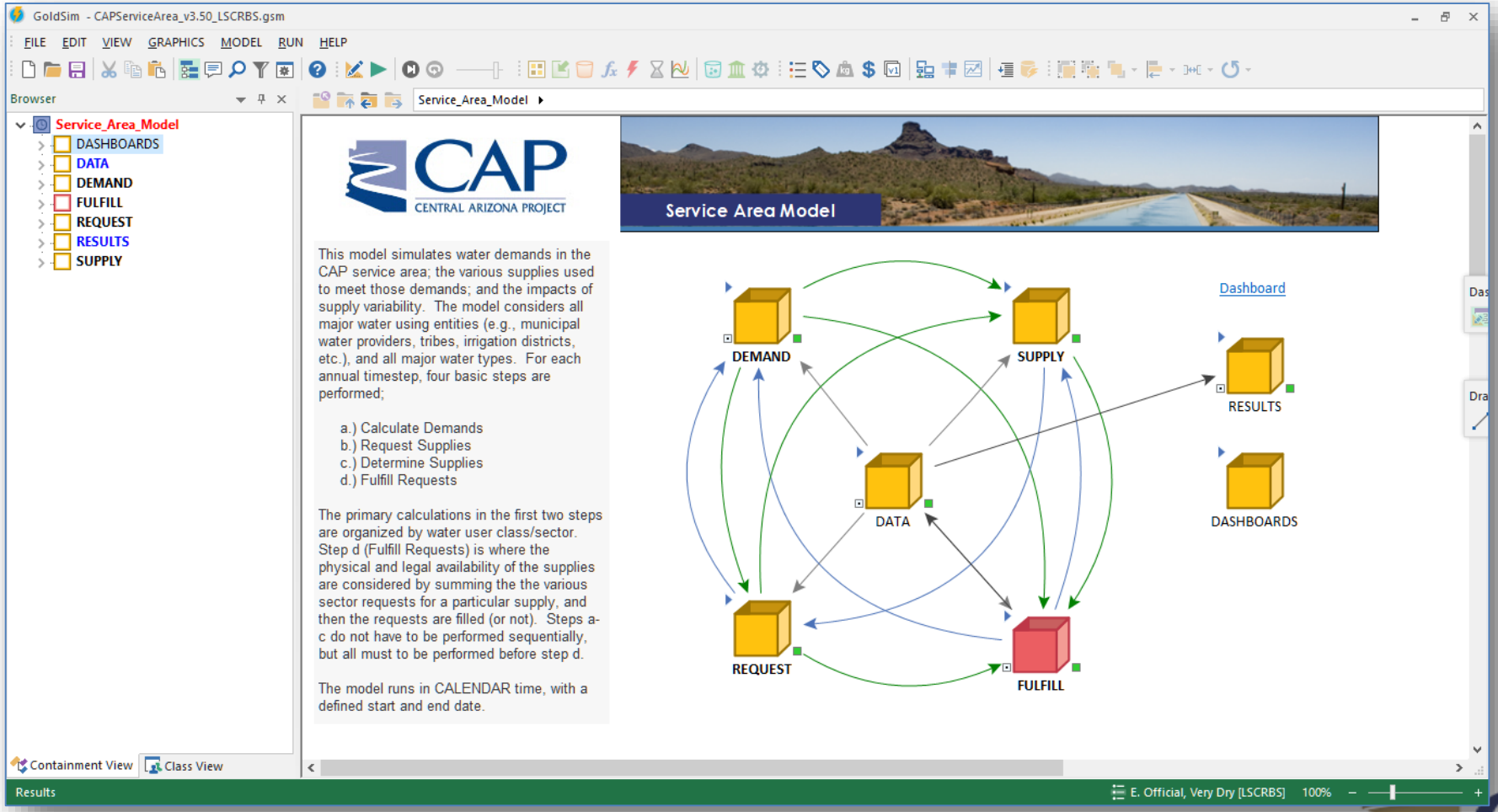
Advice from Scaling-Up in GoldSim



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Practice Good Model Hygiene

- Develop style and naming conventions
  - (e.g., data prefixes {val_, tbl_, ts_}, CamelCase, verbose names, etc.)
- Use appropriate containerization
  - At higher levels, emphasize process/system
  - At deeper levels, emphasize the math
    - Help your future self
- Limit equation complexity
  - Show each step
- Use check-in/check-out script for multiple users
  - Available in Model Library

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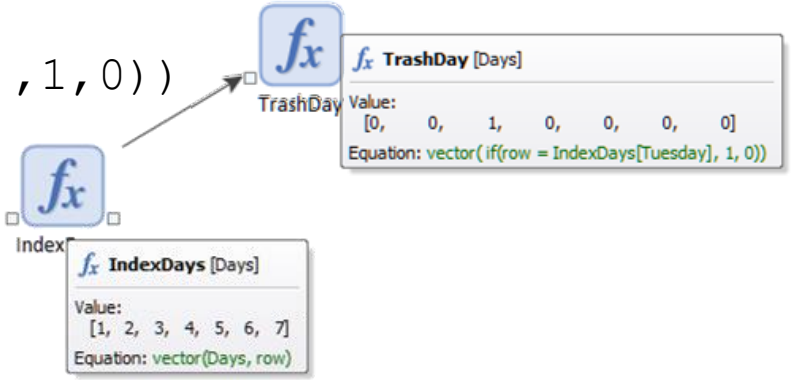
Use Arrays

- Arrays are fast, flexible and powerful
  - A single calculation can be applied to a entire class
    - Avoids duplicated Expressions
  - There is a full suite of manipulation and calculation functions
    - Right-click in Expression dialog → Functions → Array Functions
- Use named Array Labels help make your model human readable
- Use vinterp() & vindex() for dynamic lookup & manipulation
- Use an "index vector" for value insertion
    - `IndexDays = vector(days,row)`
    - `TrashDay = vector(if(row=IndexDays[Tuesday],1,0))`



Visualize in Excel

- GoldSim's charting has improved, and is well-suited for modelers, but Excel offers more capabilities
  - GS's embedded charts are a great new addition—*thanks!*
- Write GS outputs to standalone Excel and/or text file(s)
  - Put them in a separate location, and don't touch them
- Use separate Excel files, linked or connected as a data source, for charting and manipulation
  - Prevents collisions; use Refresh All & Update Links
- Make data connection to Log File for scenario & run data
  - To update Log File, use Script Element to generate a fake Warning

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Visualize in Excel

Scenario name & Description

Run Date

File version

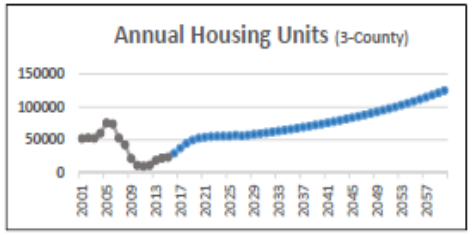
Model parameters

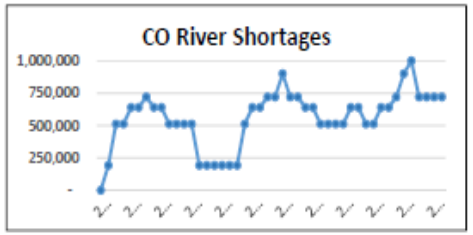
D. Dry, Rapid Outward [WVWA]

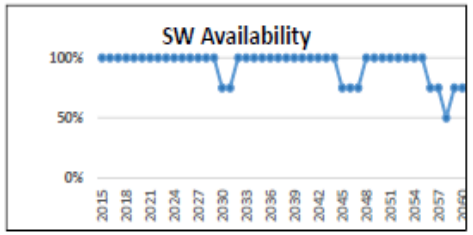
Faster growth rate, with an outward (sprawling) growth pattern, plus hotter and drier due to climate change.

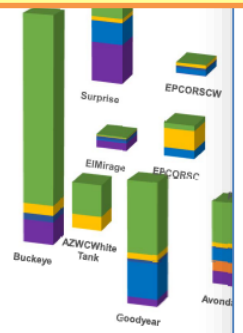
Run Date: 2/25/2018 **Filename:** CAPServiceArea_v3.20.gsm

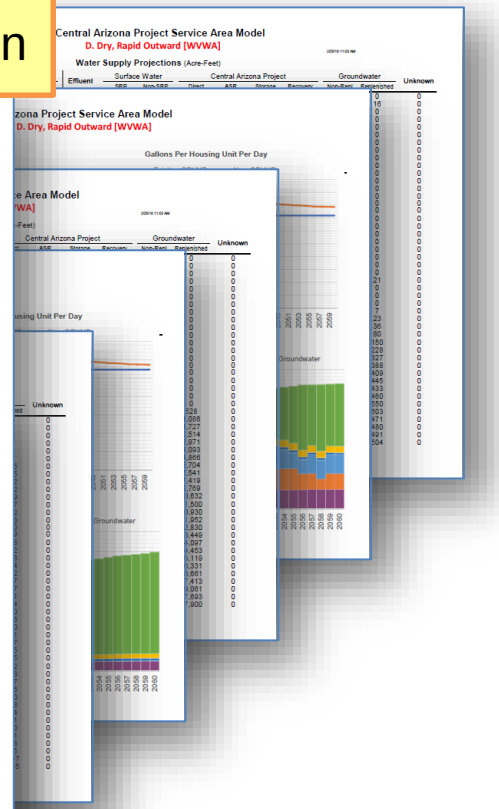
Allow Shortages	Yes	
Select CRSS Array	3	*3=Synthetic*
Use Specific Trace	Yes	
Selected Trace	2	*1=Moderate; 2=Deep; 3=Slight*
AWBA Max M&I	20%	
Surface Water Scenario	2	*1=No Reduction; 2=Occational; 3=Frequent*
Use CAP Buildup	Yes	
CAP Buildup Scenario	2	*1=2035; 2=2045*
HU Growth Pattern	3	*1=Baseline*
HU Forecast	2	*1=Use Curve; 2=Eller Forecast*
HU Curve	2	
HU Growth Start Rate	2%	
HU Ordinary Level	56,000	
HU Rate @ 50 yrs	3%	
GPHUD Change Existing	-0.3%	*per year*
GPHUD Max Change Existing	-12%	
GPHUD Min Existing	220	
GPHUD Scenario New	1	
GPHUD Change New	0.0%	*per year*
Ag Climate Adjustment	0.1	
Ag Efficiency Increase	0.1%	*per year*
Ag Efficiency Goal	80%	
Ag Replace Crop CU	2.66	
Ag Intensity Scenario	2	
Ag Develop on Crops	70%	*Percent of max on active Ag*
Ag Acres Replace Percent	0%	
Ag Replace Crop Year	2025	











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Don’t Clone

Just because you can…

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Don’t Clone

…doesn’t mean you should!

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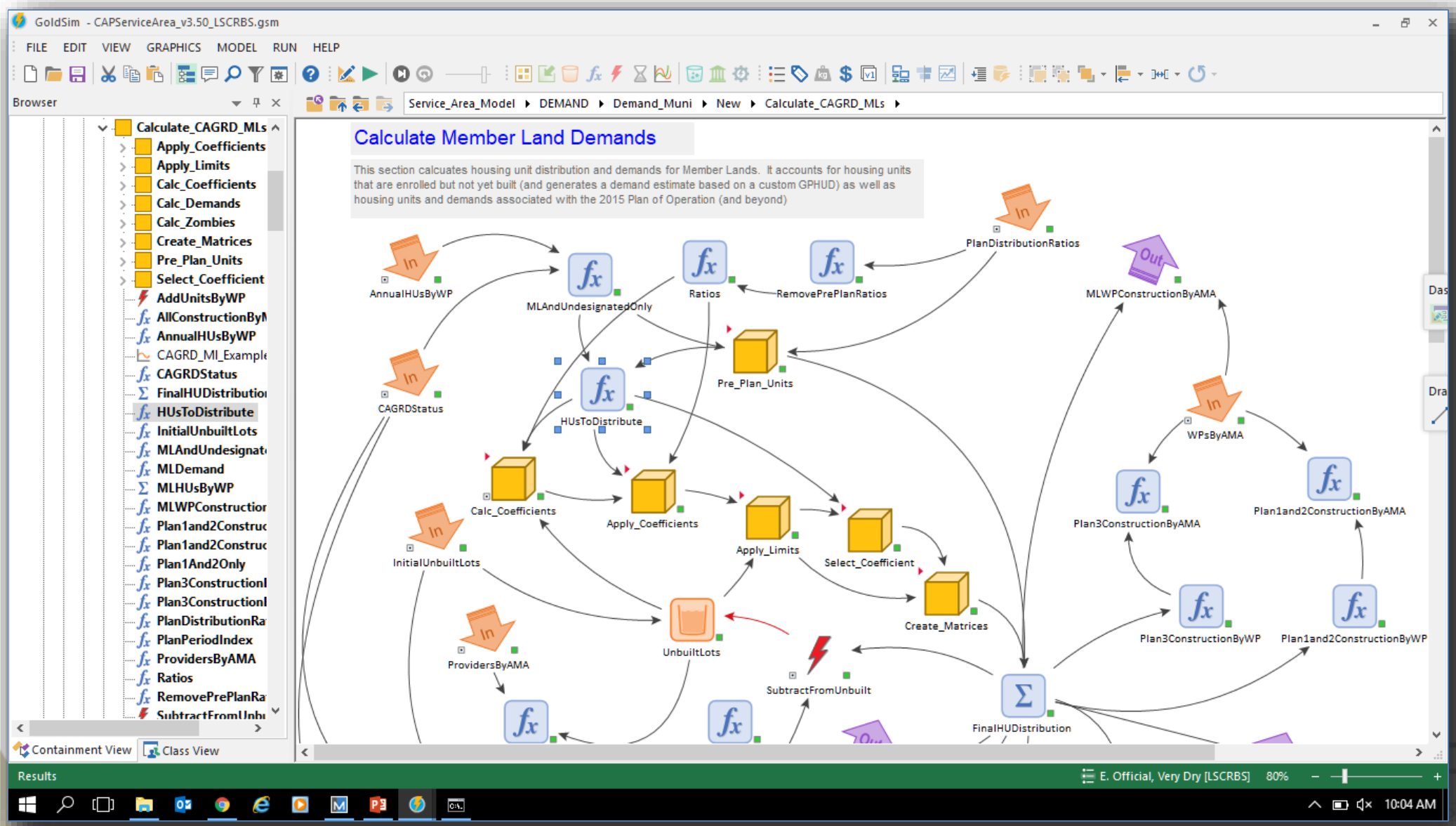
Show Ins & Outs



Now, about the Columbia River…

Ken Seasholes

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Central Arizona Project

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