Salt River Project
Water Resource Management

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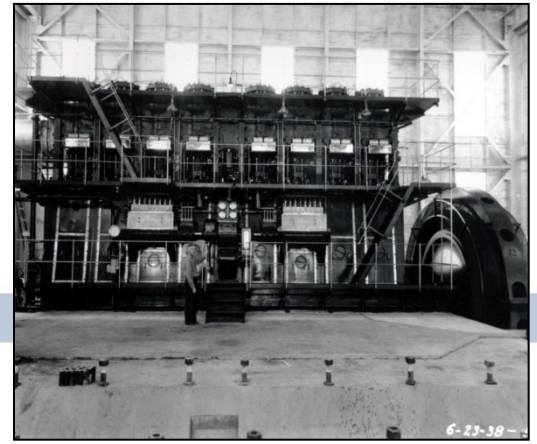
Salt River Project Structure

President Theodore Roosevelt

- Salt River Valley Water Users Association
  - Established in 1903
  - Private Corporation
  - One of the first reclamation projects under the Reclamation Act of 1902
- Salt River Project Agricultural Improvement and Power District
  - Established in 1937
  - Political Subdivision of the State of Arizona
  - Allowed for the growth of power generation and service



Crosscut Diesel Plant, 1938

SRP manages seven reservoirs on the Salt (4) and Verde (2) rivers in Arizona for a 13,000 sq. mile watershed (plus 1 on East Clear Creek), operates canals and groundwater wells in the 250,000 acre service area, and currently delivers nearly 800,000 acre-feet of water per year.

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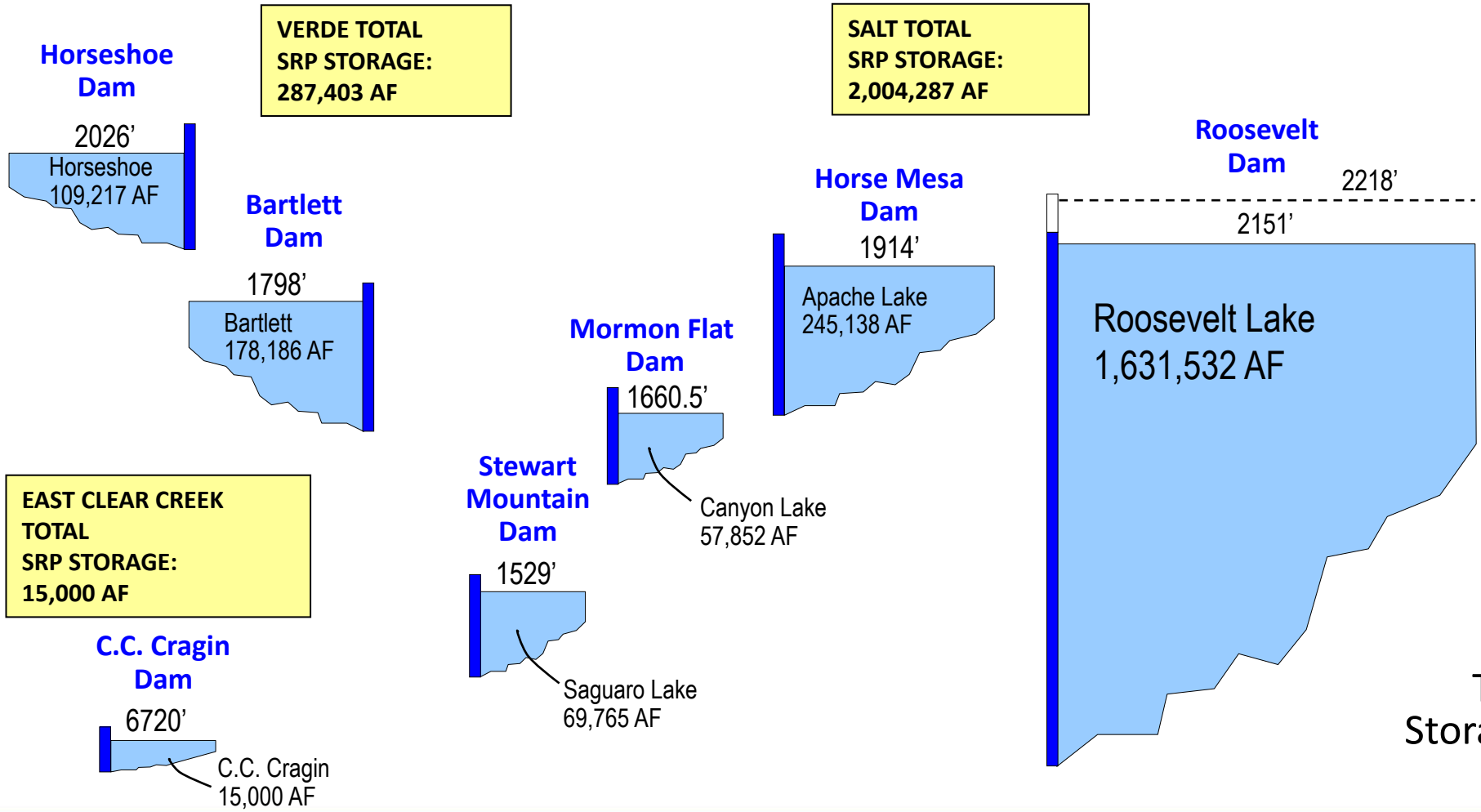
Salt and Verde Watersheds

SRP Reservoir System Capacity in Acre-Feet



Total Reservoir Storage: 2,306,690 AF

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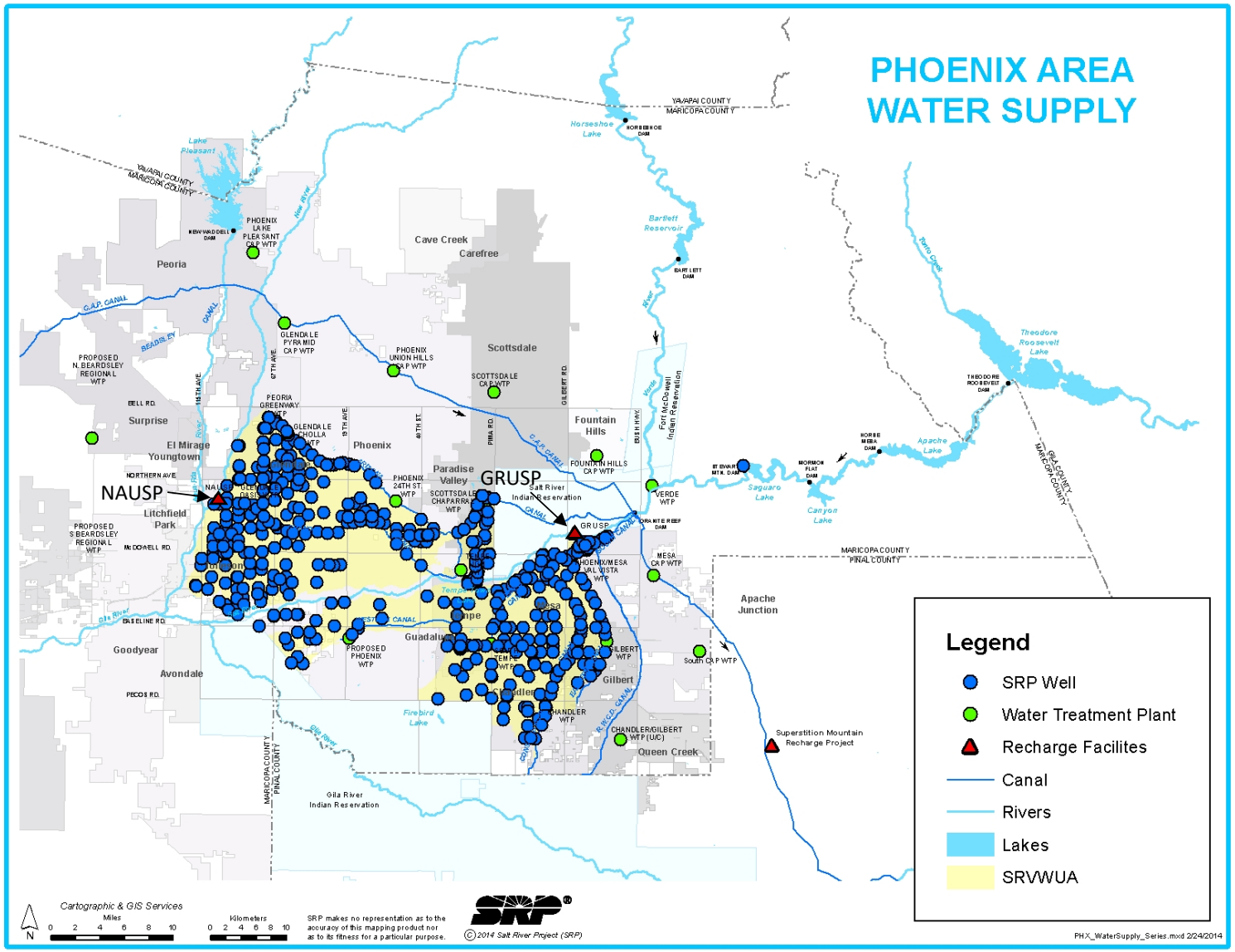
SRP Water Delivery System



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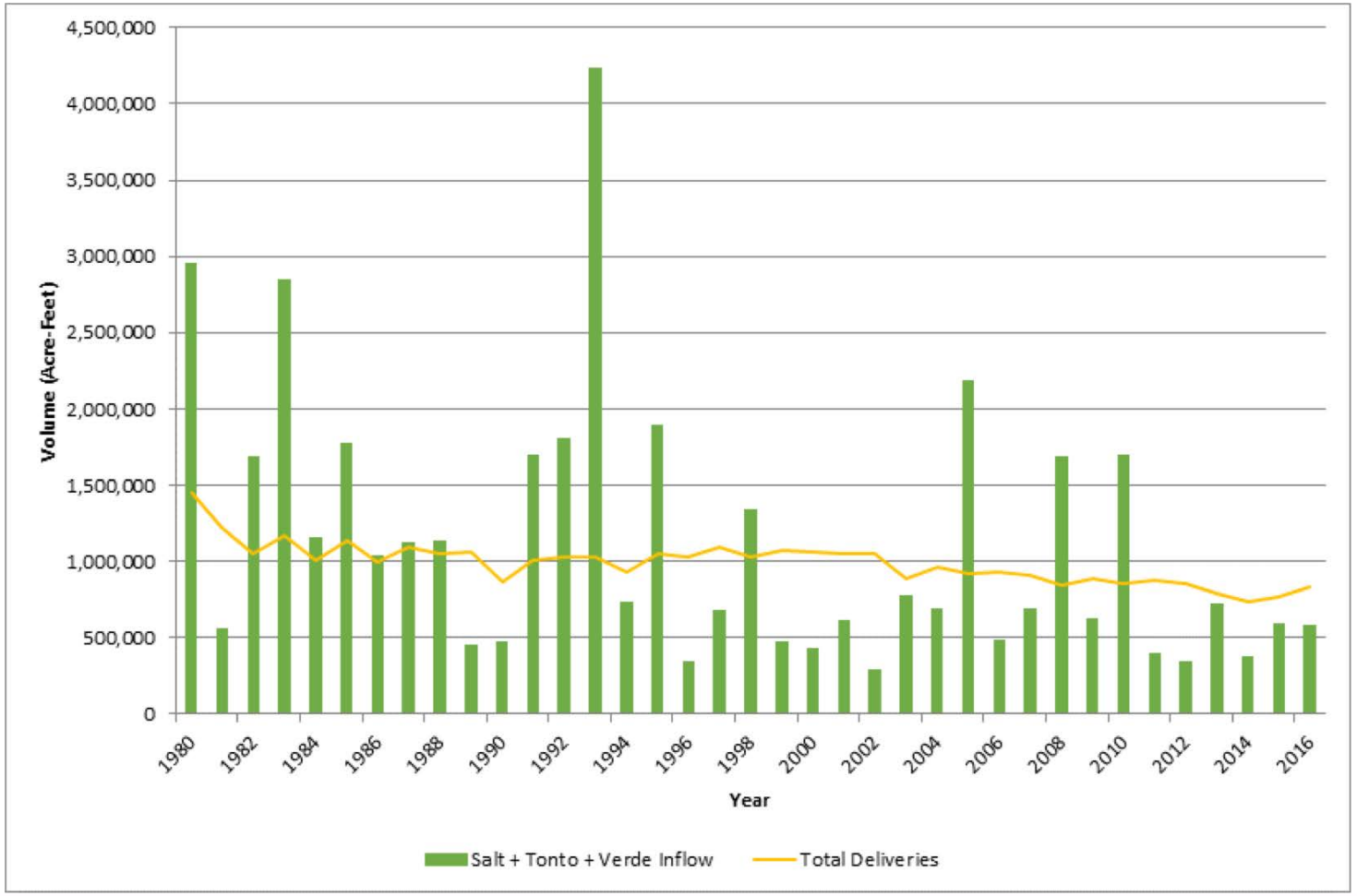
Creating Dependability from Variability



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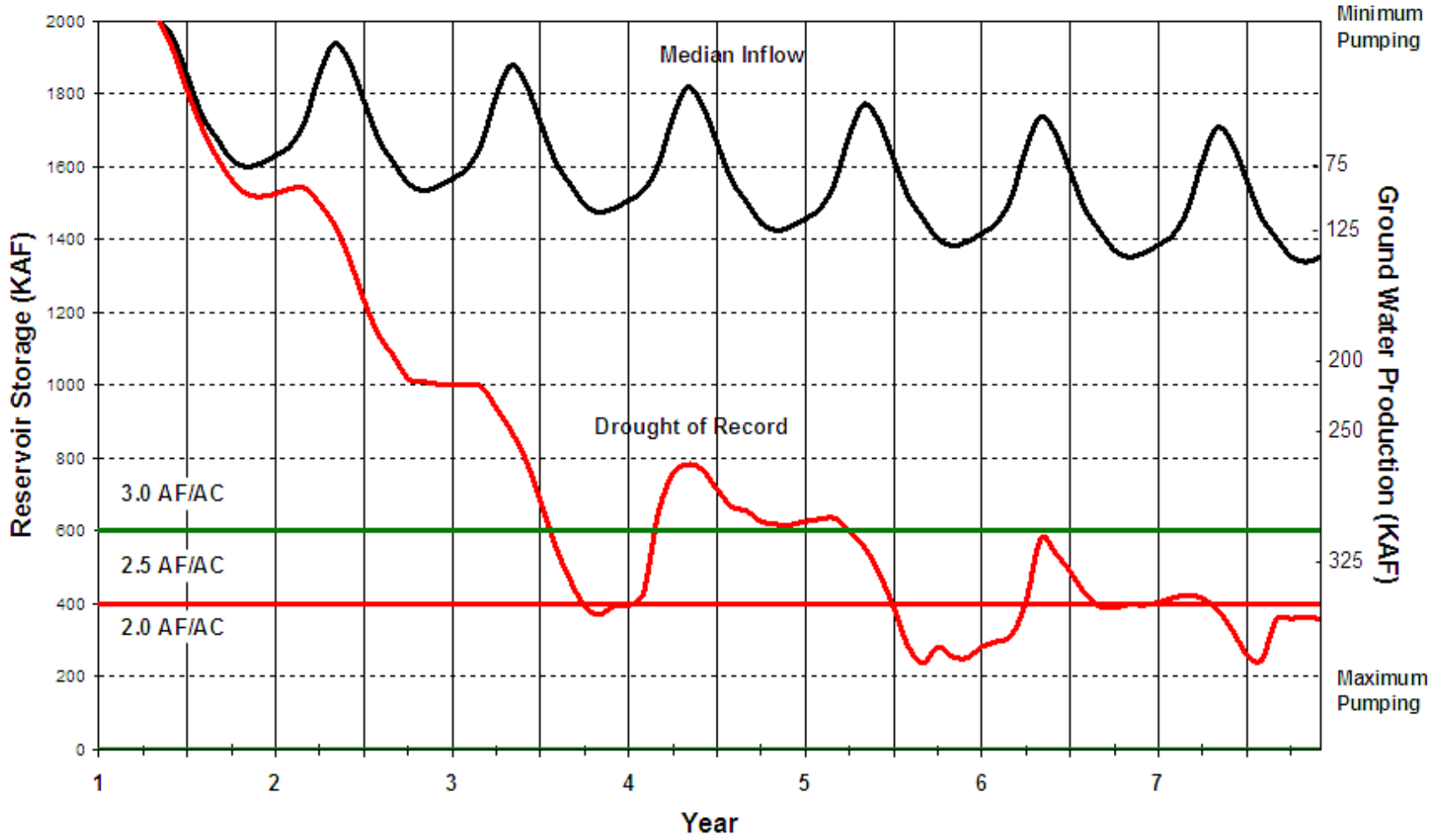
Water Resource Planning in the 1980s and 1990s

Planning Assumptions

- 950,000 AF Full Demand
- 325,000 AF Maximum Pumping
- Historical Drought Of Record 1898-1904
- Allocation/Pumping To Manage For Drought Of Record
- Allocation Setting Process Used to Manage Demand

Water Resource Planning in the 1980s and 1990s



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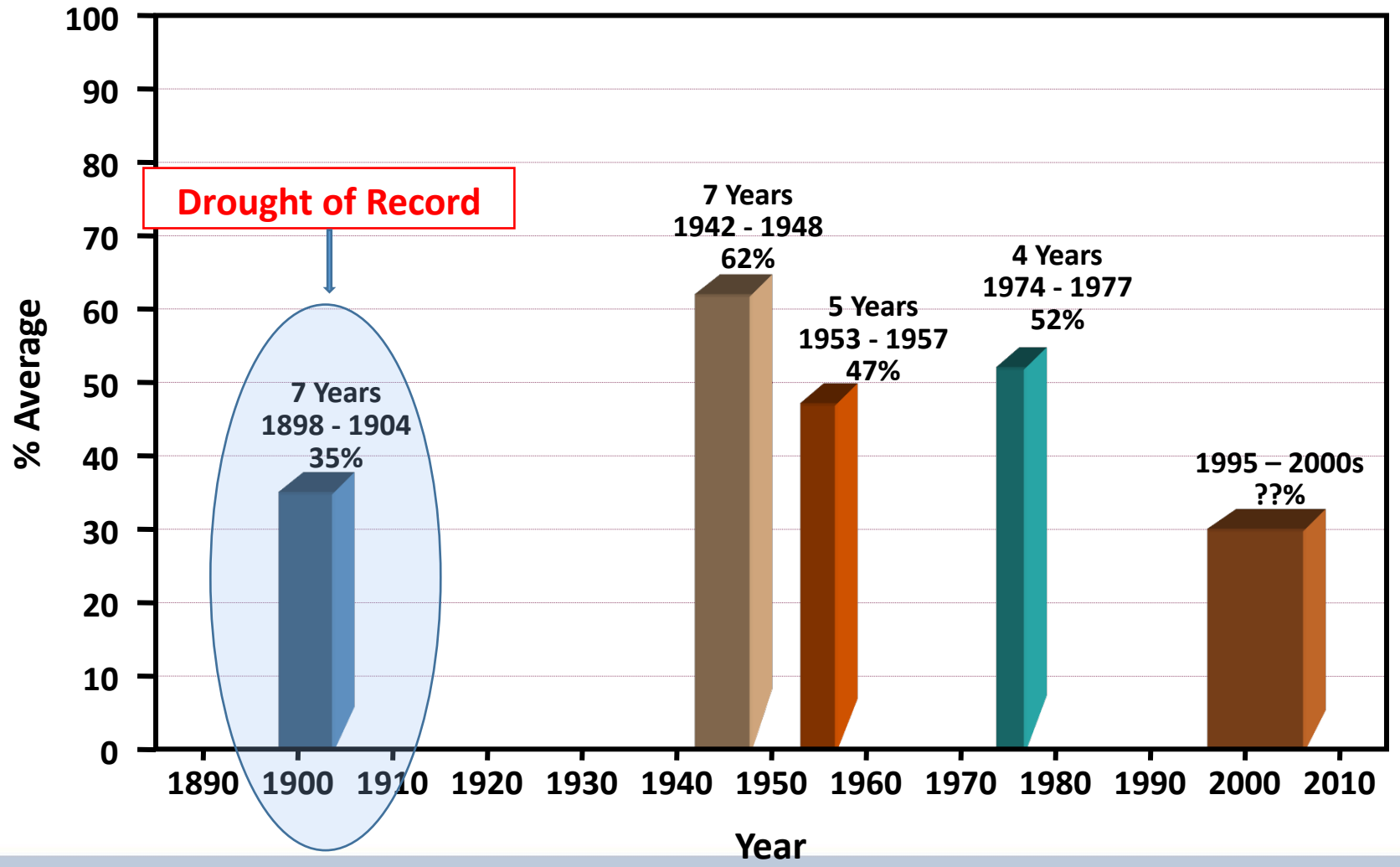
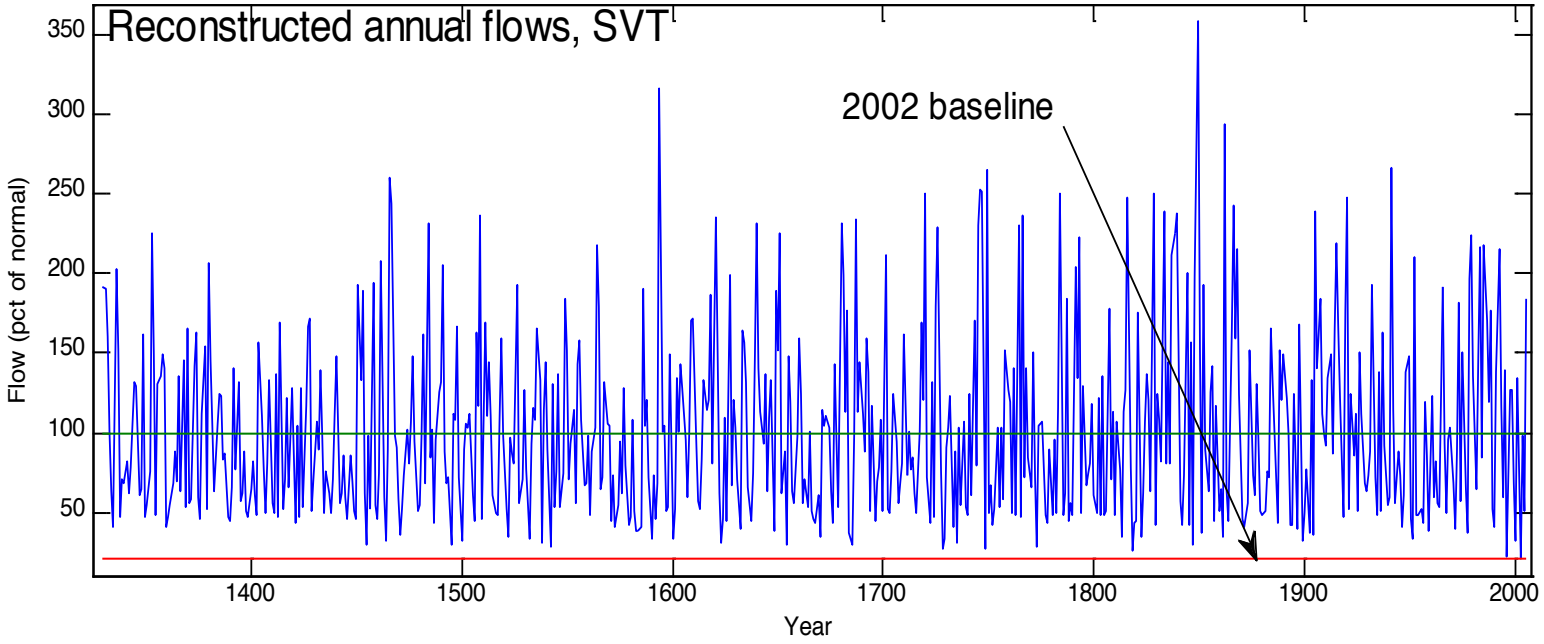
Water Resource Planning in the 2000s



What Can Tree-Ring Analysis Tell Us About Pre-20th Century Droughts?

1996 and 2002: Long-term Extreme Lows

- Reconstructed flow was 21% of normal* in 2002, 22% of normal in 1996
- No other reconstructed flow from 1330 to 2005 was lower than 25% of normal.
- Tree growth recovered with wetter conditions in 2005



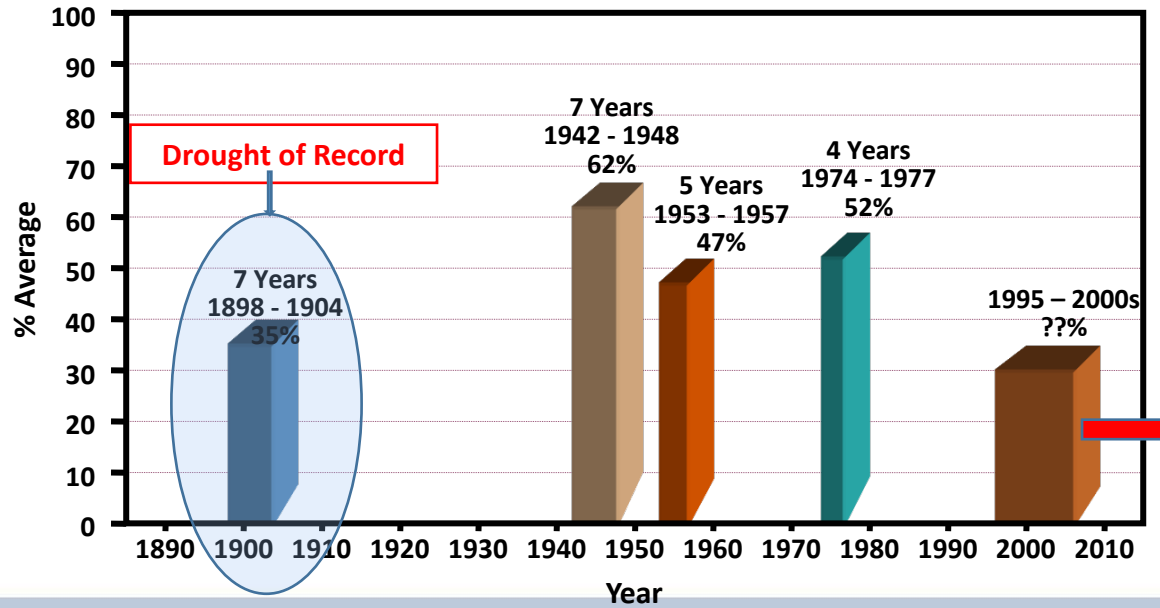
LABORATORY OF TREE-RING RESEARCH
UA SCIENCE

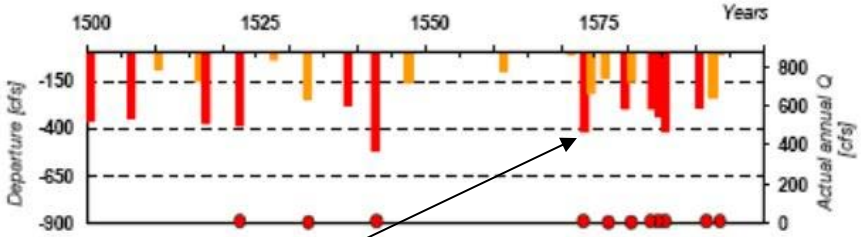
How Vulnerable Are We?

What is minimum annual inflow that allows SRP to maintain carryover storage in perpetuity? (i.e., the reservoir system does not dry up)

Examined:

- Historical, instrument-era record (110 years)
- Tree-ring record (1,000 years)





Tree Ring 11-year Drought of Record

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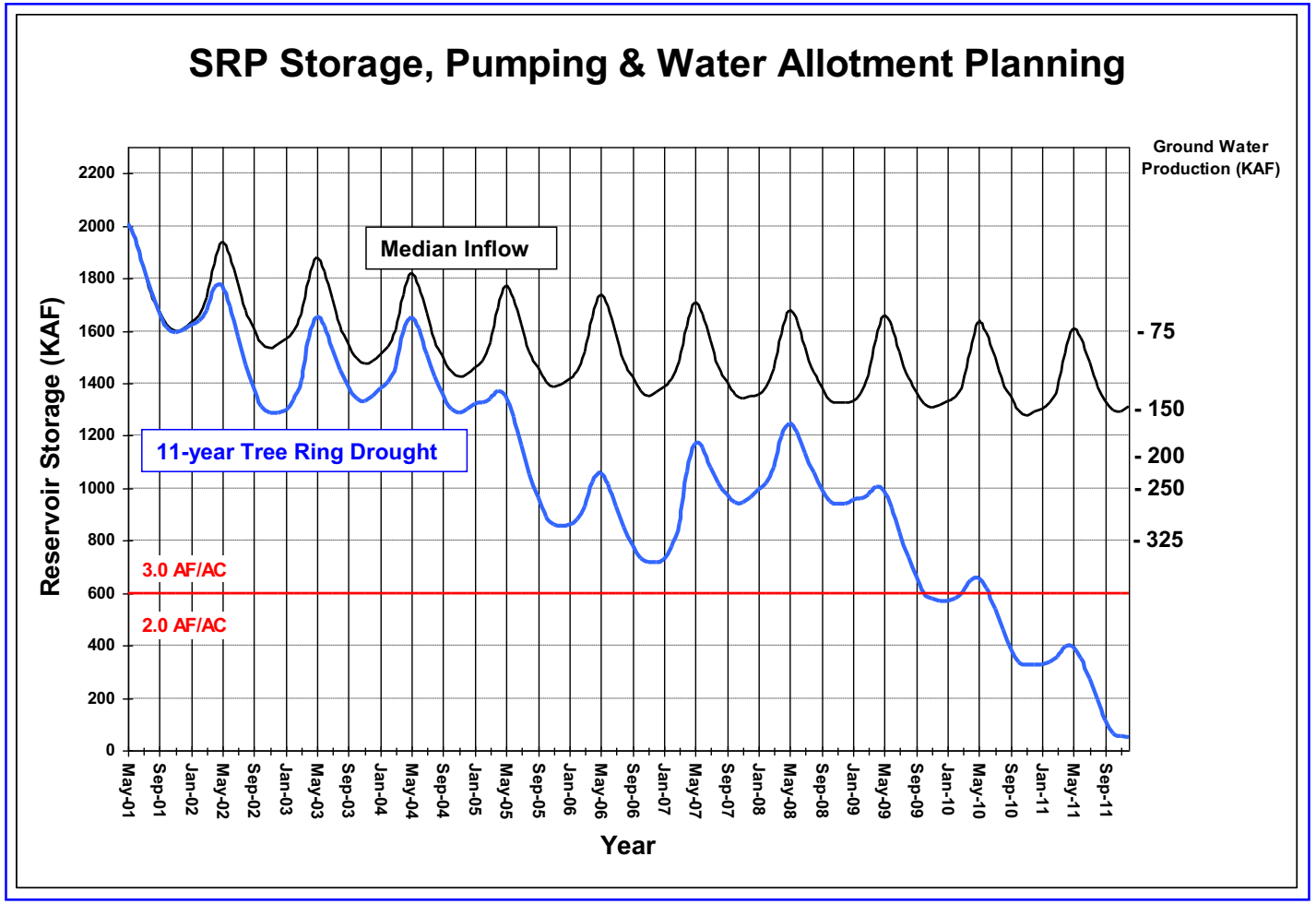
Water Resource Planning in the 2000s

Planning Assumptions

- 900,000 AF -- full demand
- 325,000 AF -- maximum pumping (start earlier)
- Tree-ring drought of record, 1575-1585
- Use revised allocation and pumping plan to manage for the 11-year tree-ring drought
- Demand mostly urban



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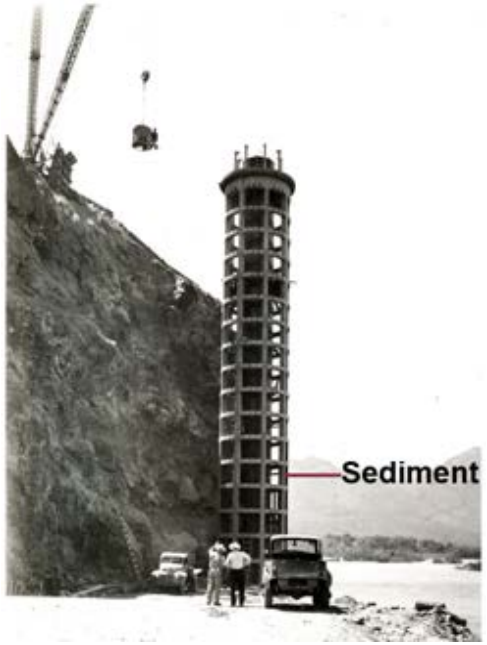
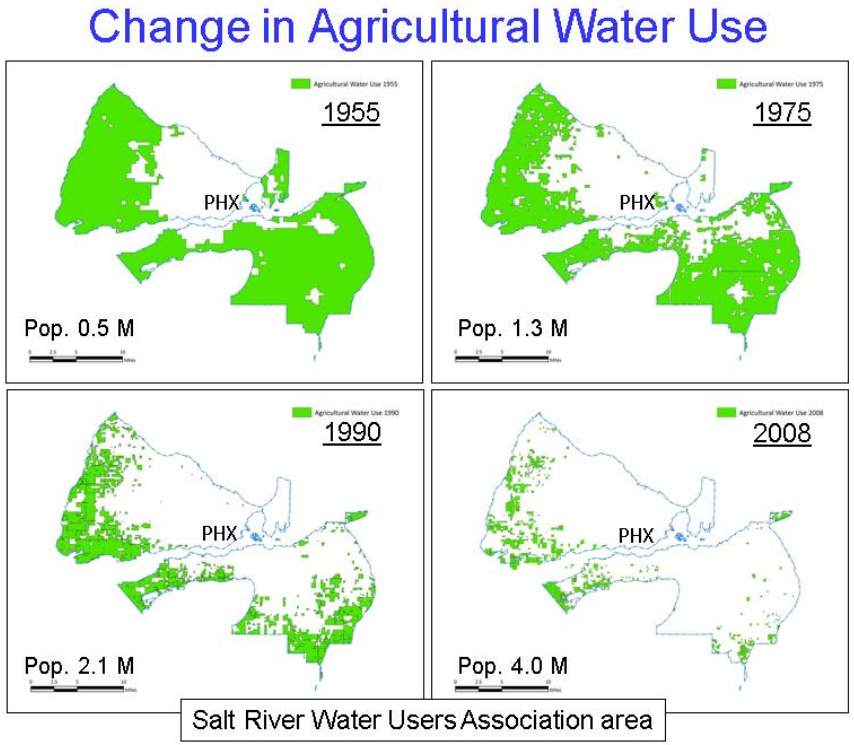
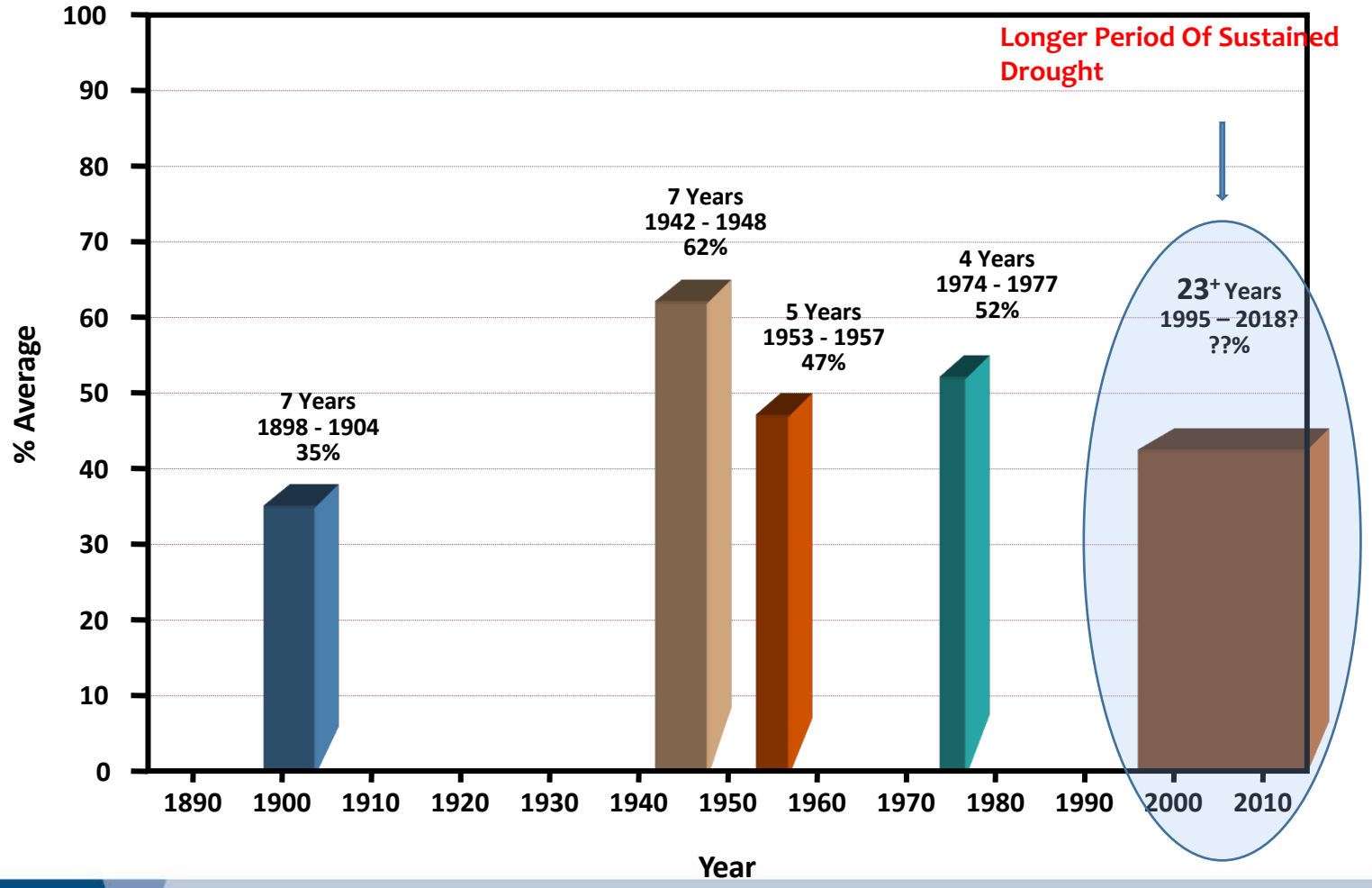
Water Resources Planning Environment

- Inflow Variability (Climate Variability)
- Sedimentation
- Changing Demand and Customer





Water Resource Planning Environment



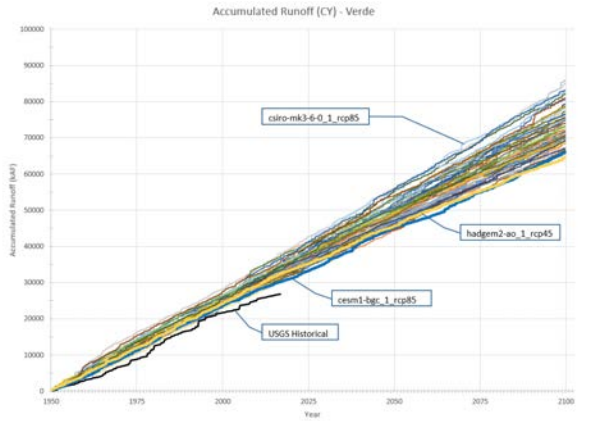
Reservoir Planning Model (RPM)

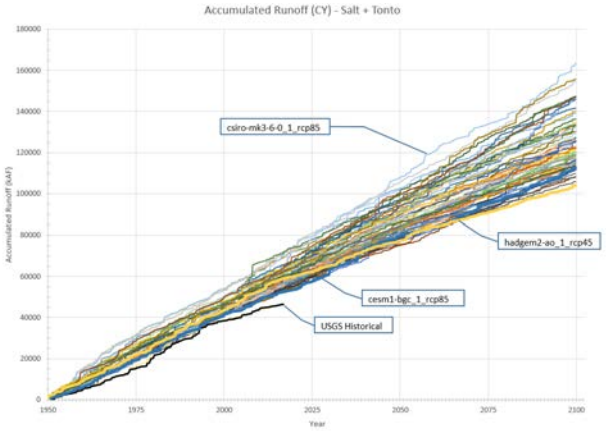
Developed by HydroLogics

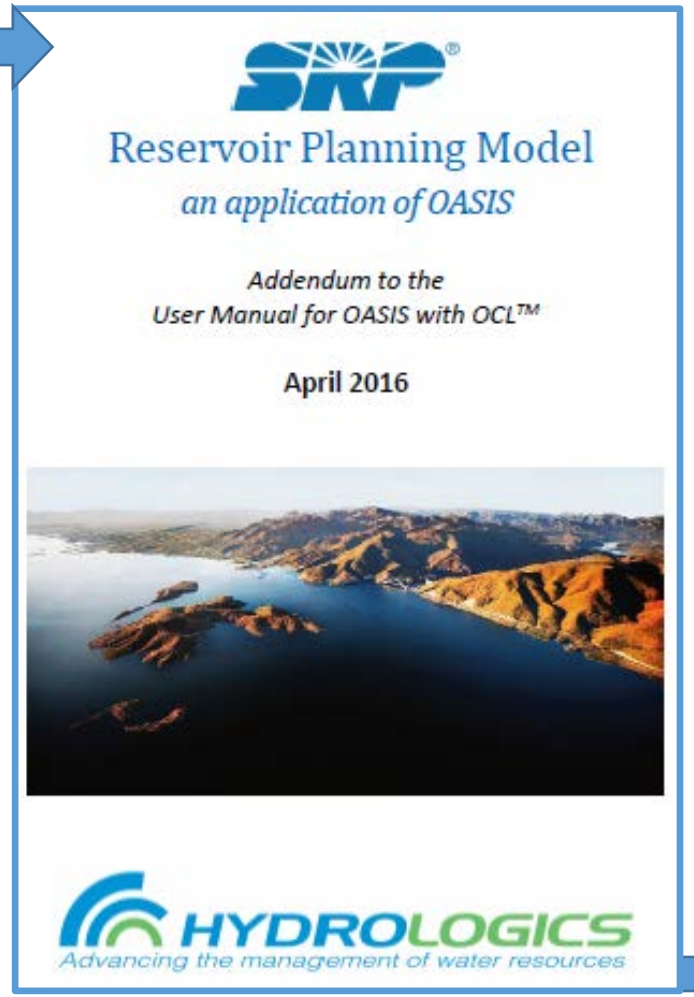
Climate Analysis and Uncertainties

Streamflow Forecasting

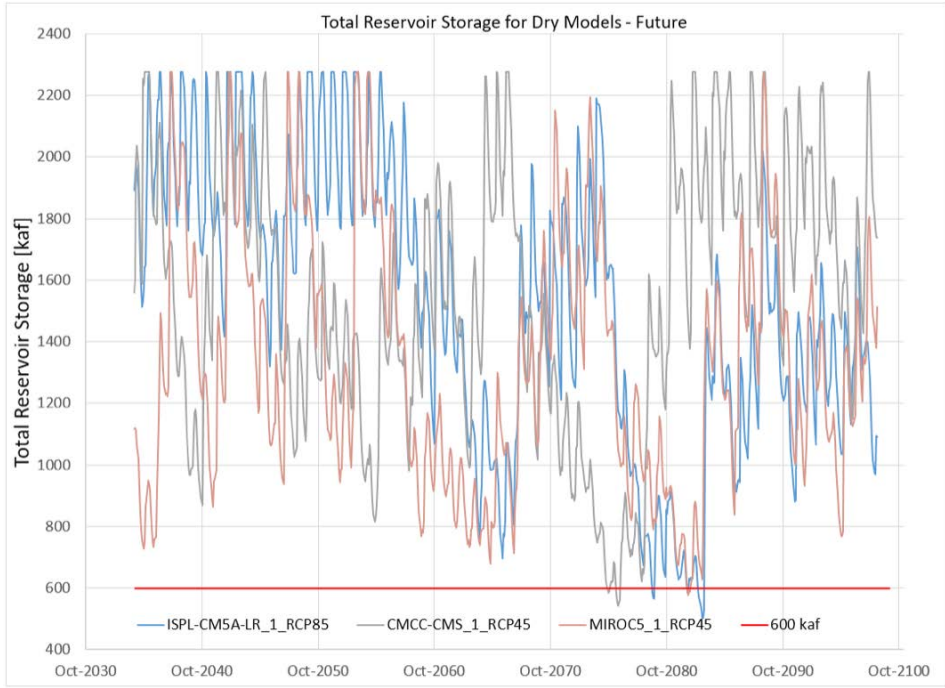
Streamflow Projection





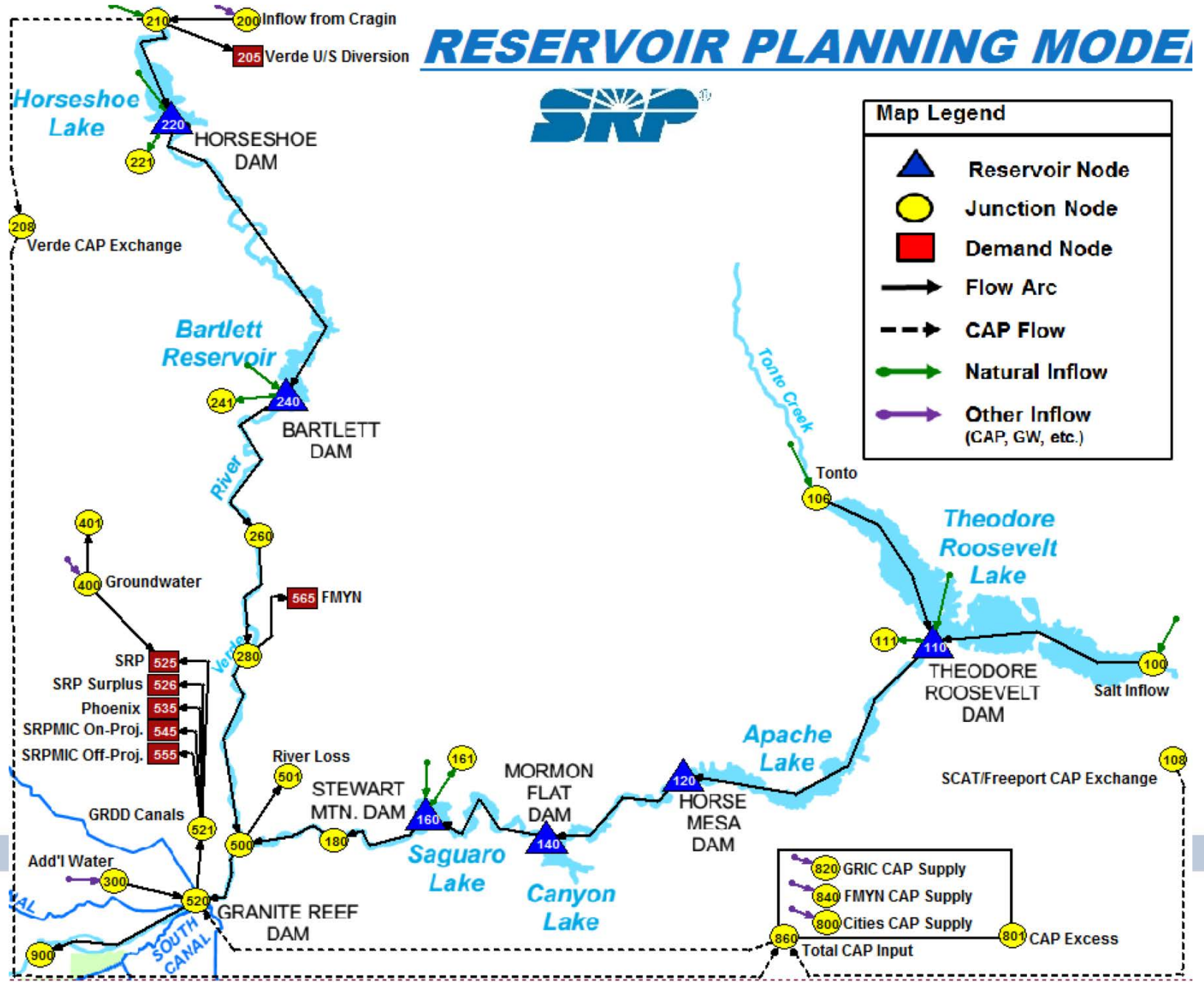


System Health



RPM

- Inflow
  - Local (ungauged inflow)
- Reservoir Operations
- Deliveries
- Groundwater
- Reservoir/River Losses



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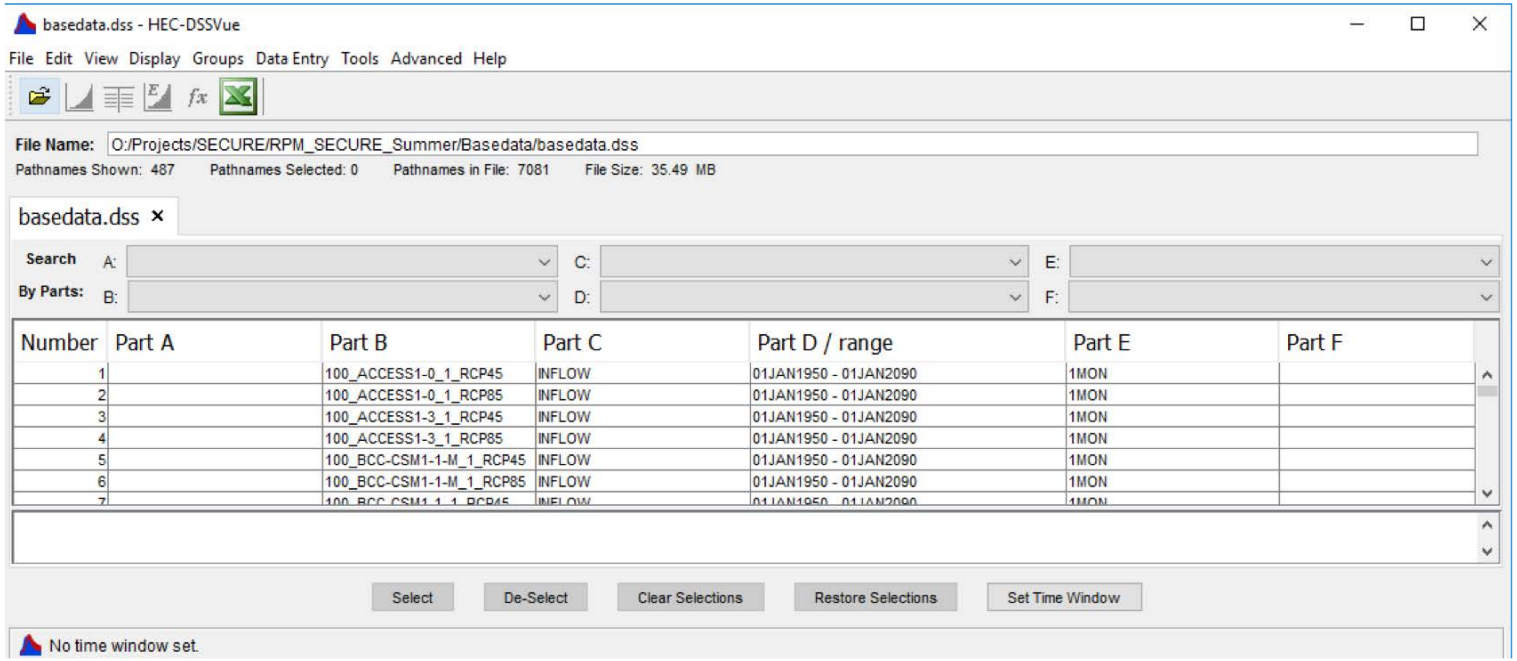
Running the RPM

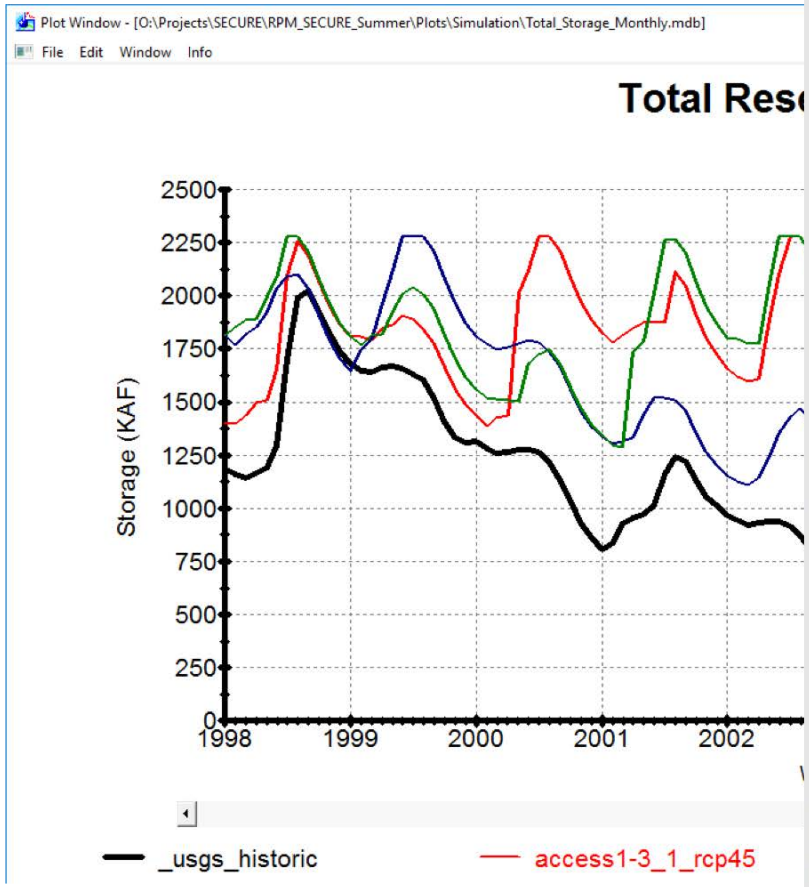
- Monthly time-step
- Can run through GUI
- Batch run
  - SRP Python script used to batch inflows into dss
  - Hydrologics executable for batch run
- 64 runs takes less than 10 minutes



RPM Output

- Detailed output for storage, demands, deliveries, exchanges, losses, spills, etc.
- Variety of standard reports and graphs
- Ad hoc reports and graphs
- Calculates various statistics about output data

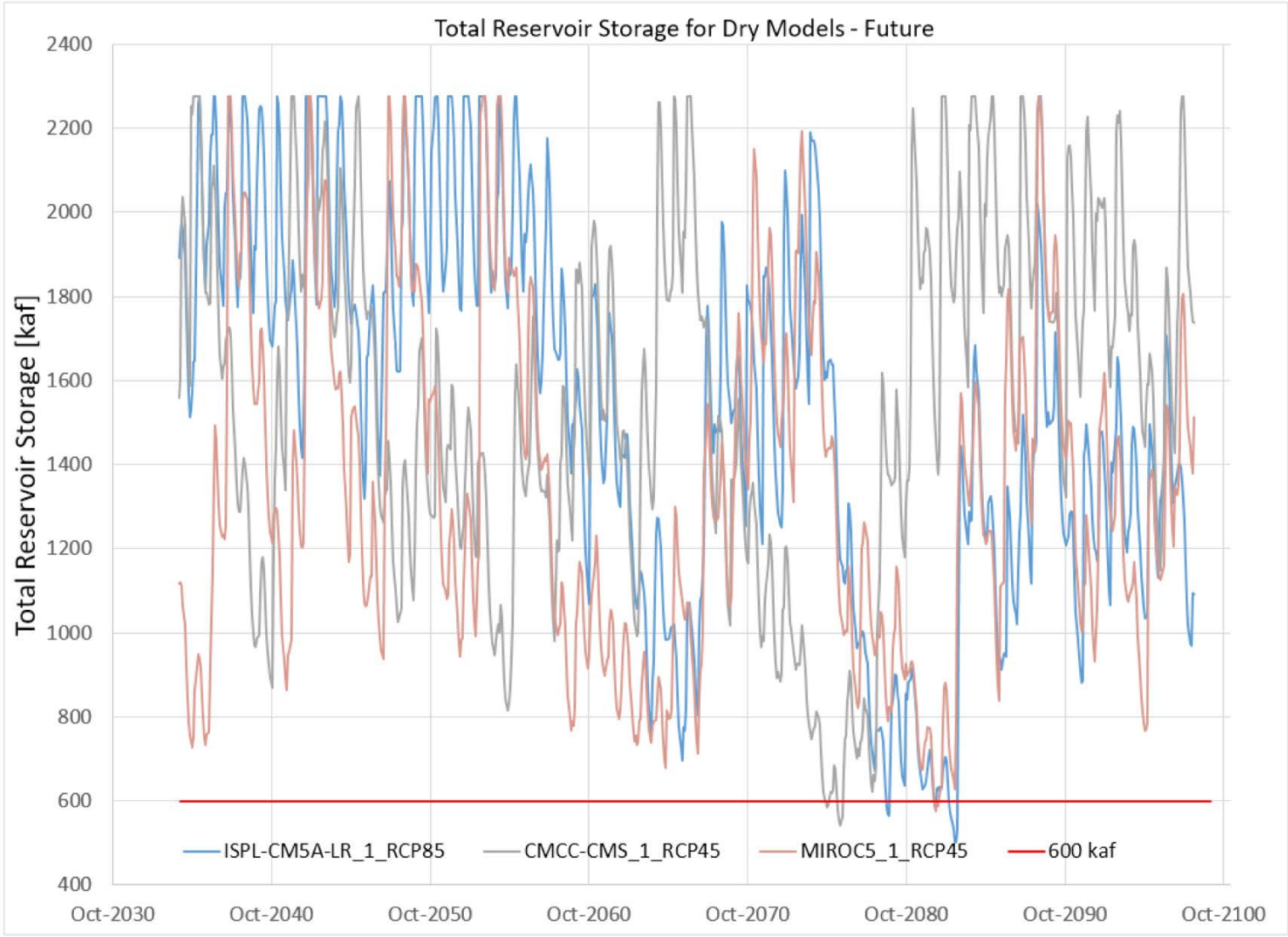
Examples of RPM Output



DATE	Verde Tangle KAF	Salt-Roos +Tonto KAF	V T+ST +Tonto KAF	Salt Spill KAF	Verde Spill KAF	Total Spill KAF	Total Demand KAF	SRP Demand KAF	Total Delivery KAF	Groundwat Pump KAF
1914	395	459	925	0	0	0	835	700	814	190
1915	871	1593	2653	744	292	1036	866	746	978	98
1916	1277	2360	3850	2191	874	3066	866	730	970	65
1917	893	707	1710	421	341	762	866	730	995	65
1918	500	349	895	0	158	158	866	730	875	65
1919	542	879	1533	0	0	0	866	730	965	65
1920	1266	1621	3156	1716	876	2592	866	737	1002	65
1921	310	511	856	0	0	0	866	762	845	65
1922	783	529	1474	165	348	513	866	751	959	65
1923	537	492	1150	0	61	61	866	730	902	65
1924	548	770	1451	386	203	589	866	730	966	65
1925	264	291	591	0	0	0	835	736	814	65
1926	513	631	1300	0	0	0	866	773	850	65
1927	818	793	1777	269	341	610	866	730	978	65
1928	314	282	631	0	0	0	866	730	849	65
1929	390	408	862	0	0	0	866	746	845	65
1930	287	472	796	0	0	0	866	771	845	65
1931	403	547	1042	0	0	0	866	764	845	65
1932	835	1169	2229	636	427	1063	866	735	940	65
1933	220	426	693	0	0	0	866	731	845	65
1934	164	236	420	0	0	0	835	720	814	65
1935	506	748	1347	0	0	0	866	780	845	152
1936	287	637	979	0	0	0	866	766	845	88
1937	819	878	1872	465	420	885	866	730	940	65
1938	436	354	835	0	114	114	866	734	877	65
1939	275	346	656	0	0	0	835	720	814	65
1940	220	297	530	0	0	0	835	764	814	114
1941	1158	1925	3418	1113	558	1671	865	763	1000	76
1942	286	555	895	88	13	101	866	730	921	65
1943	286	528	881	0	0	0	866	731	852	65
1944	429	329	836	0	0	0	866	730	895	65
1945	394	490	957	0	0	0	866	731	845	65
1946	215	302	554	0	0	0	835	720	814	65
1947	197	284	528	0	0	0	835	764	814	91
1948	236	465	729	0	0	0	825	773	804	176
1949	497	714	1326	0	0	0	852	804	846	200
1950	238	195	460	0	0	0	821	795	800	98
1951	211	197	489	0	0	0	821	800	800	152
1952	623	1185	2033	170	52	222	860	782	978	175
1953	197	243	491	0	0	0	866	730	845	88
1954	292	349	681	0	0	0	835	720	814	91
1955	213	219	493	0	0	0	835	764	814	123

Purpose of the RPM

- Current and future shortages
- Average surface water supply
- Future groundwater supply
- Effect of physical changes to reservoirs (i.e. increased conservation storage)
- Effects of operational changes to reservoirs
- Changes in demands
- Changes in exchanges and transfers
- Sedimentation effects



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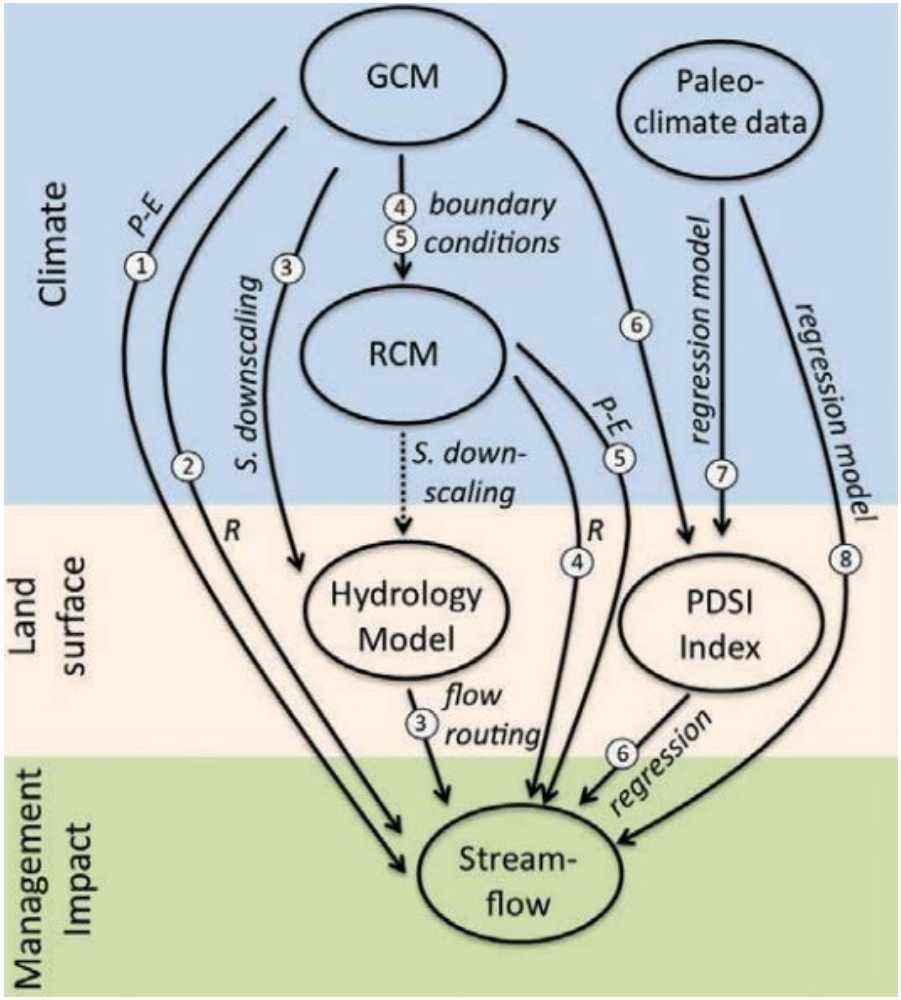
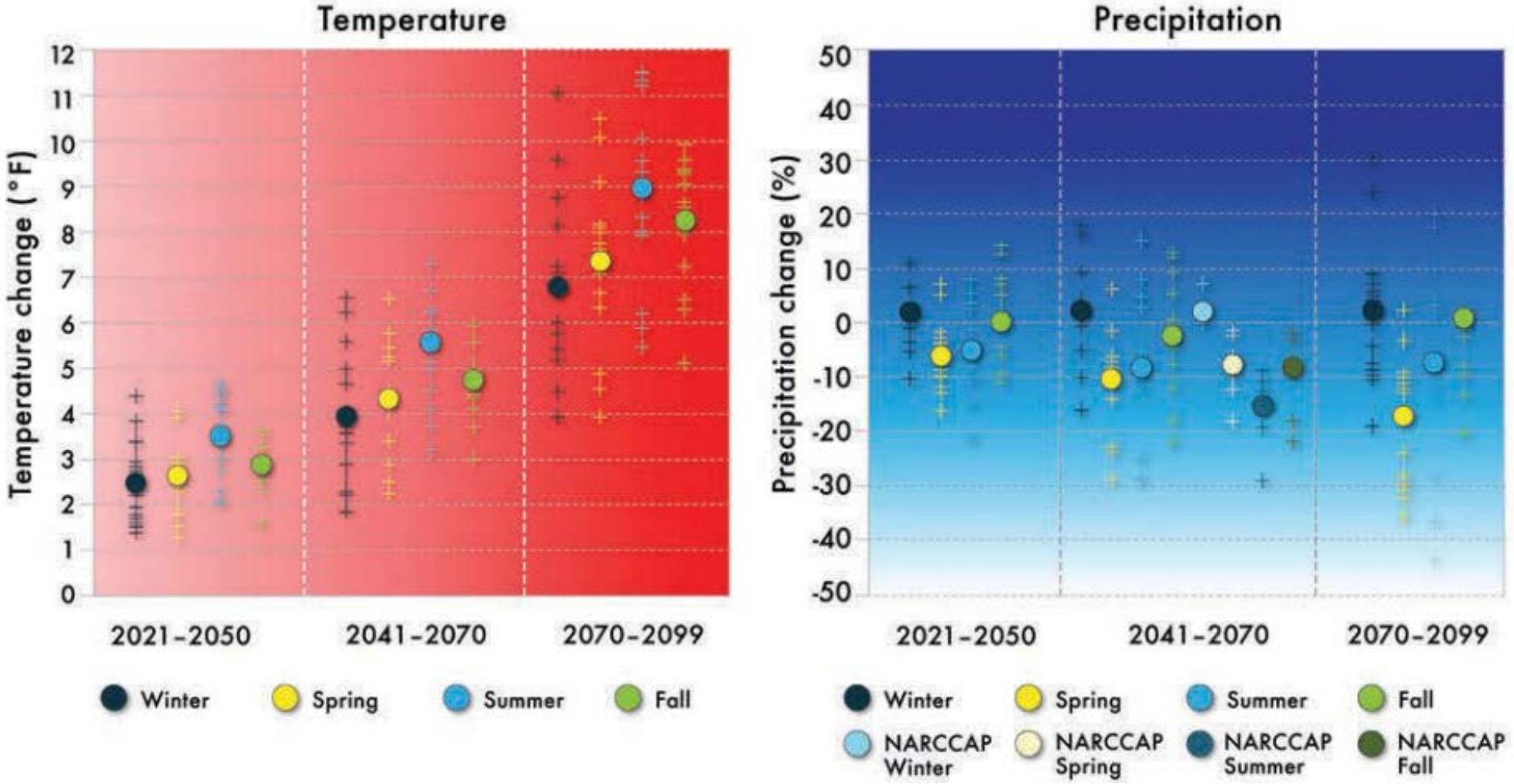
Challenges With Uncertainties

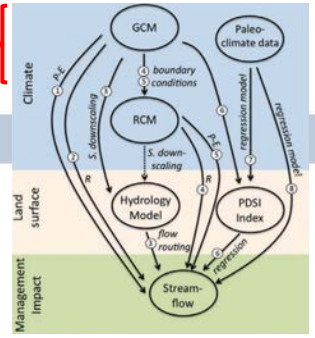


Vano et al. (2014, BAMS)

Challenges With Uncertainties



Mearns et al. (2009, Eos Transactions)



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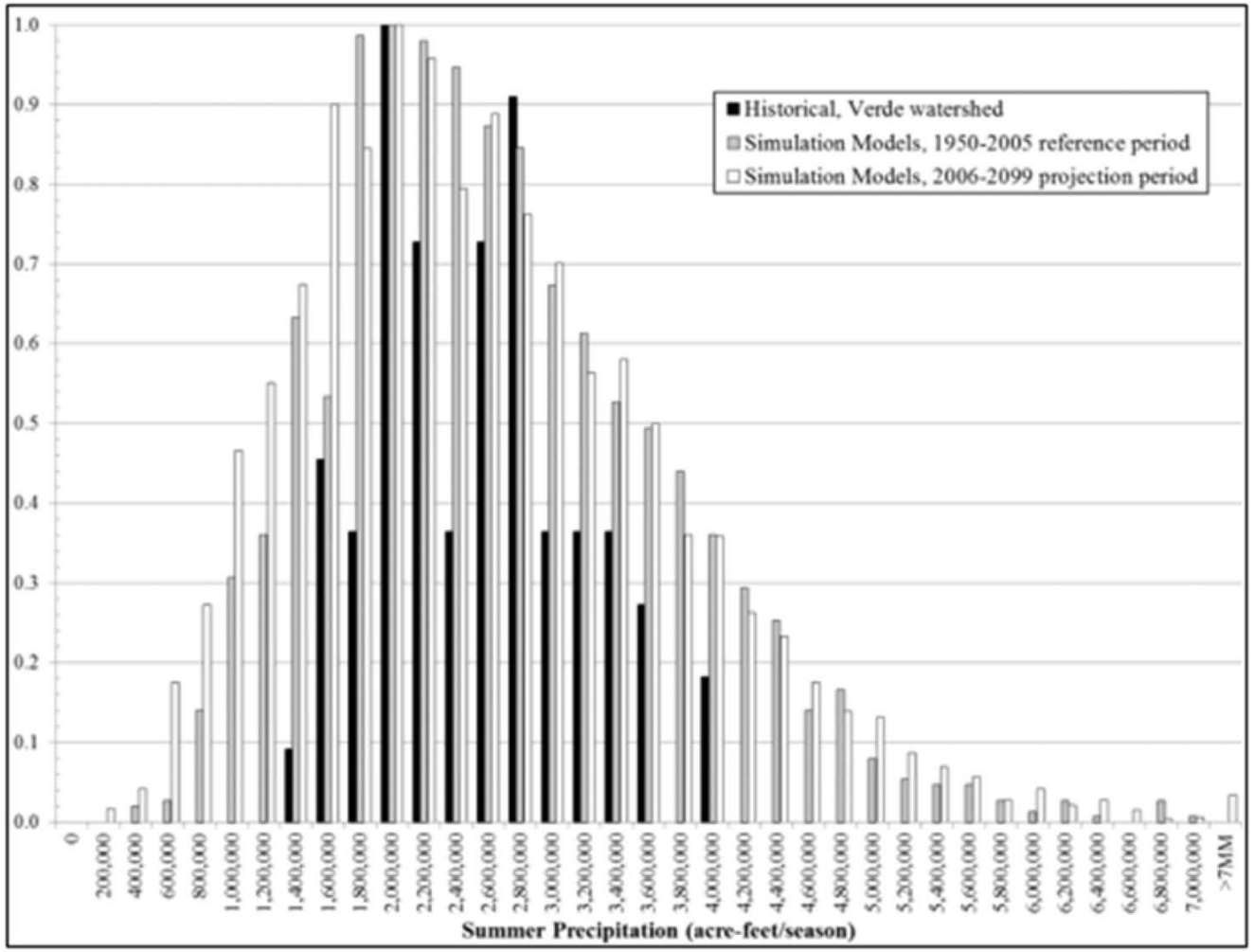

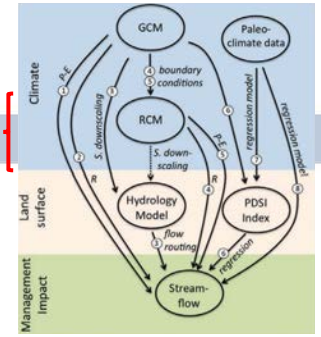

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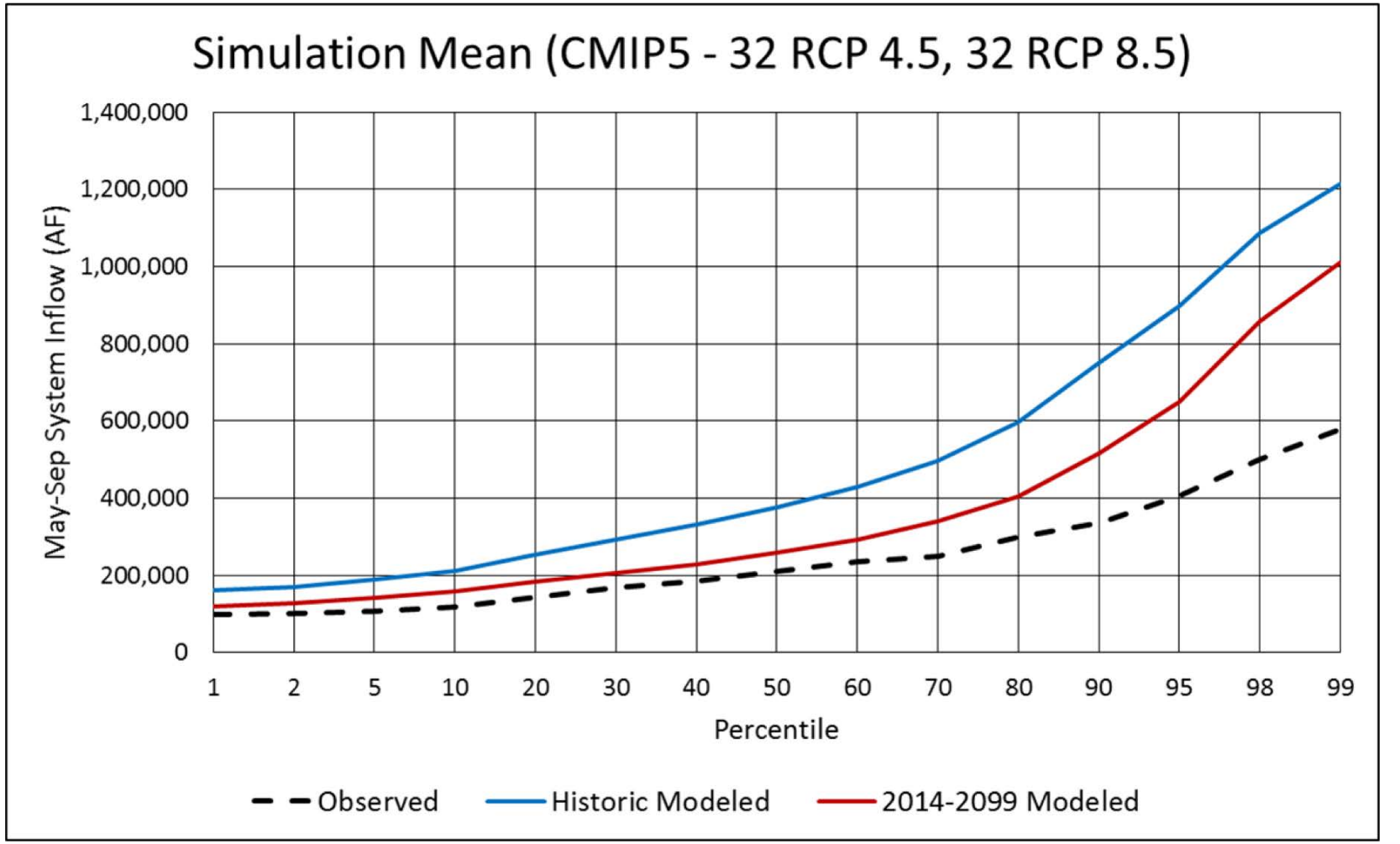

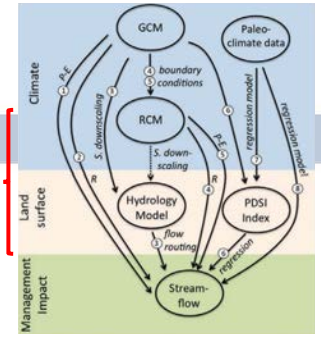

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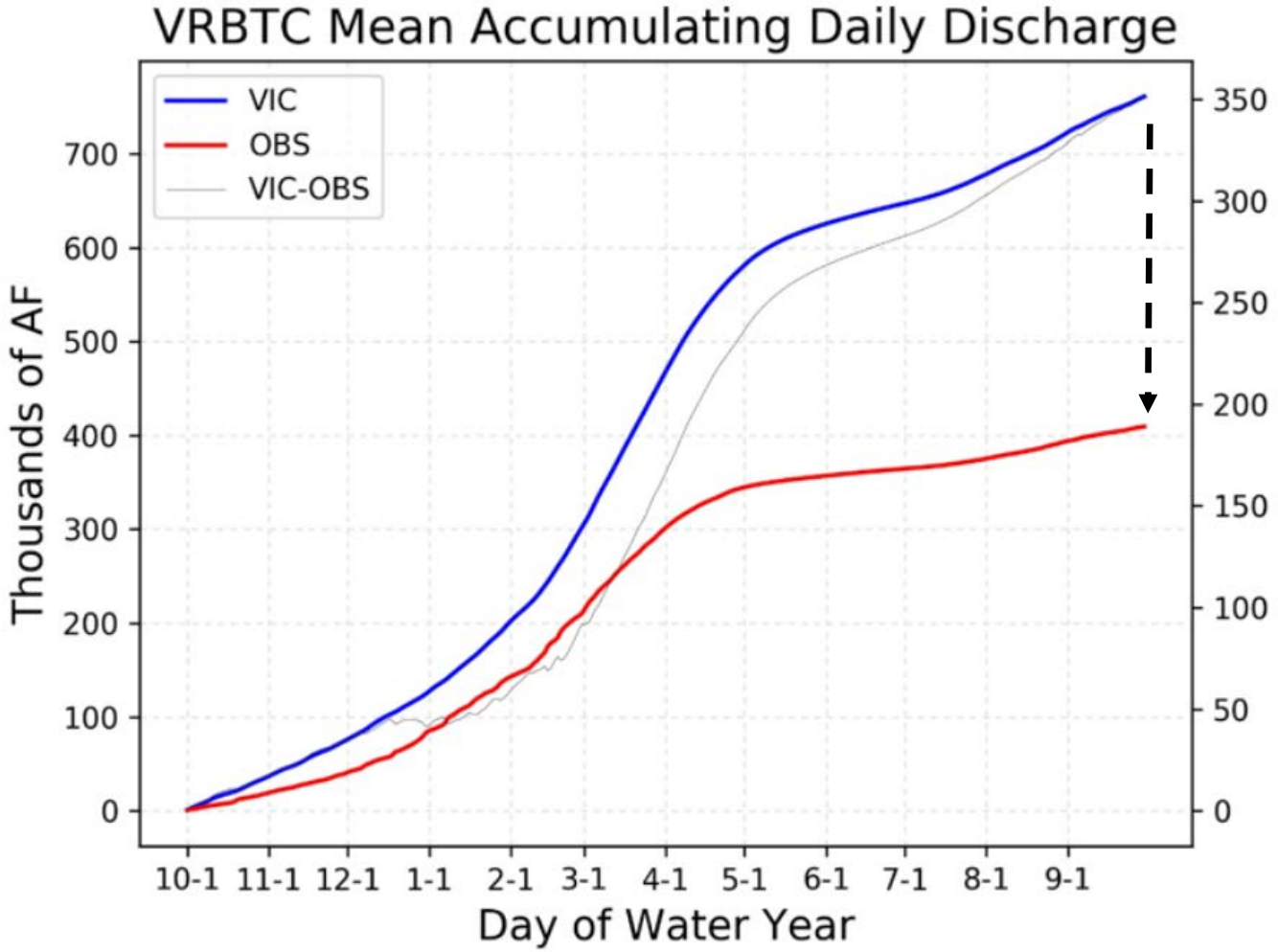

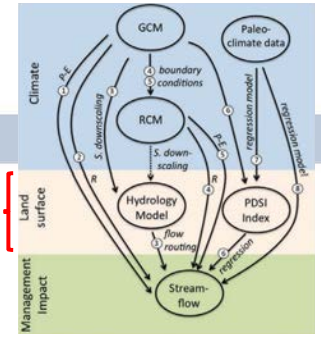

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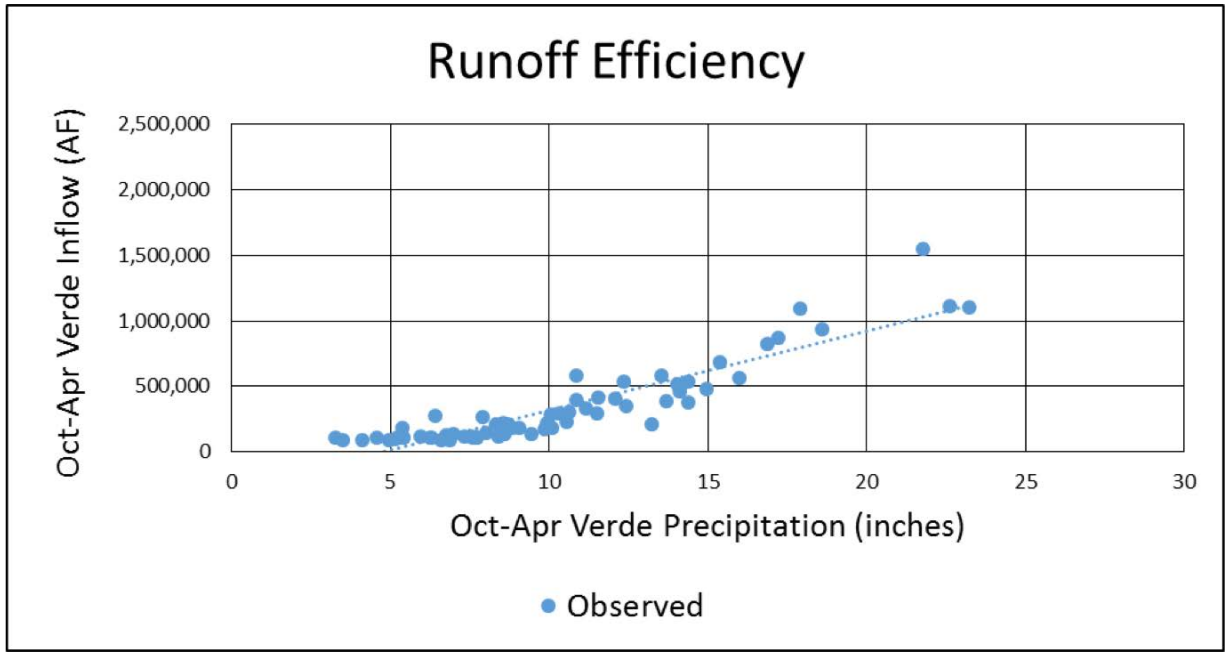
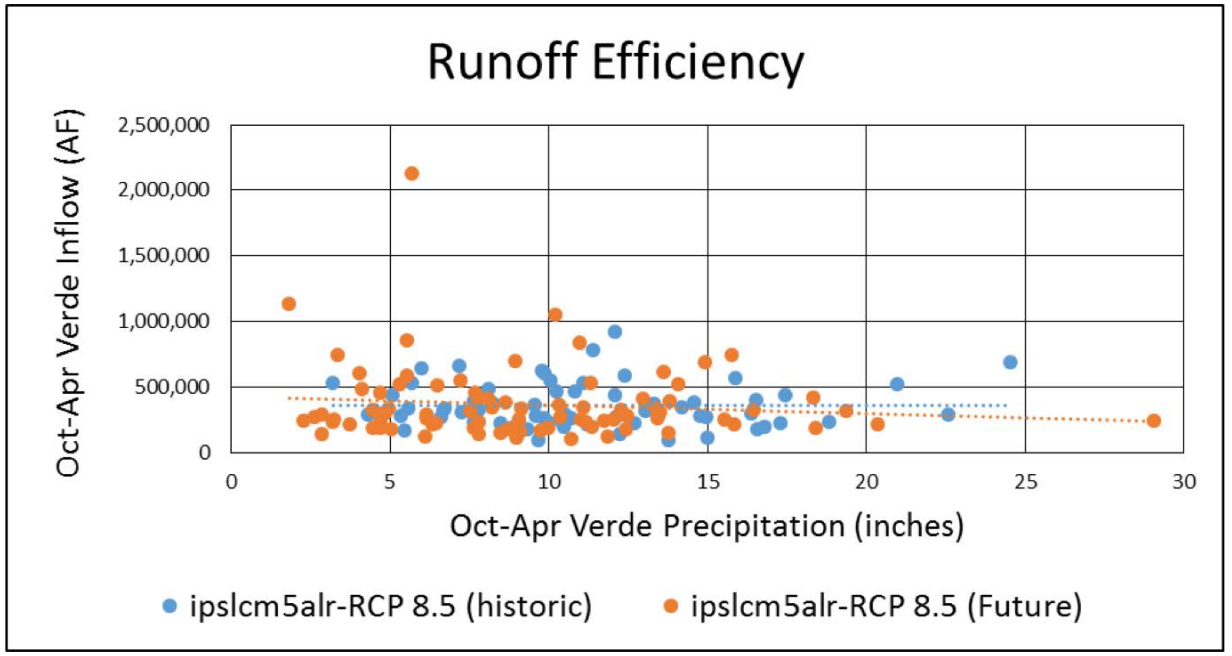
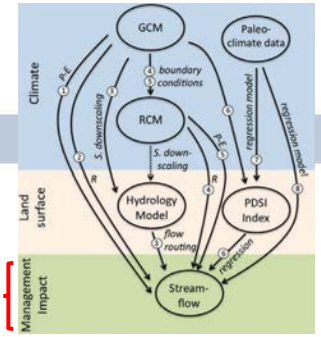




	Oct-Apr Precipitation (inch)	Oct-Apr Inflow Volume (Kaf)
1981-2010 Obs Normals	**7.93**	**189**
1993 Obs	20.93	1,548
ipslcm5alr1rcp85 1957	22.58	294
2002 Obs	3.09	88
ipslcm5alr1rcp85 1964	3.21	529



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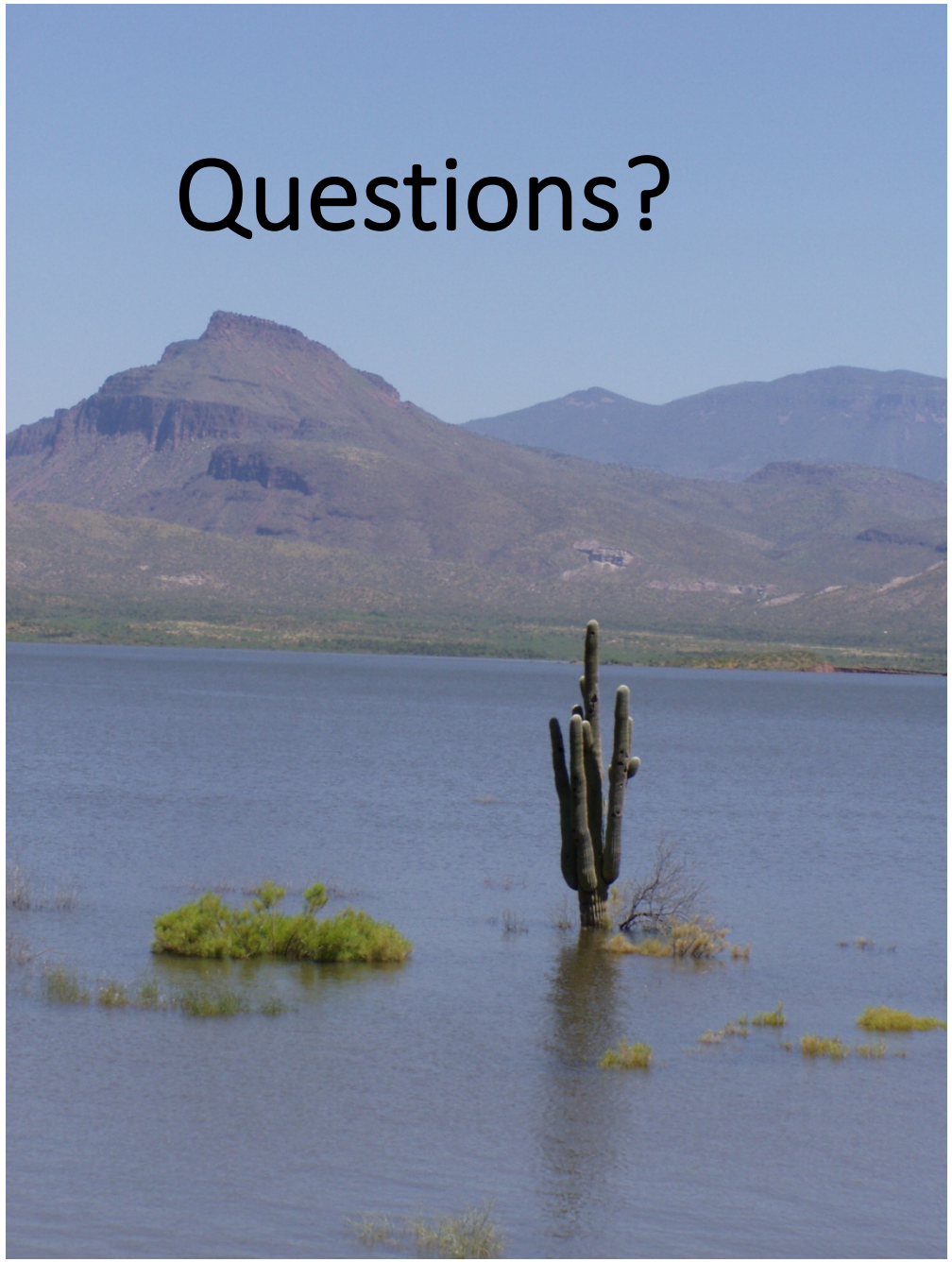
Questions?



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