Climate Change and Water Resources Challenges in California

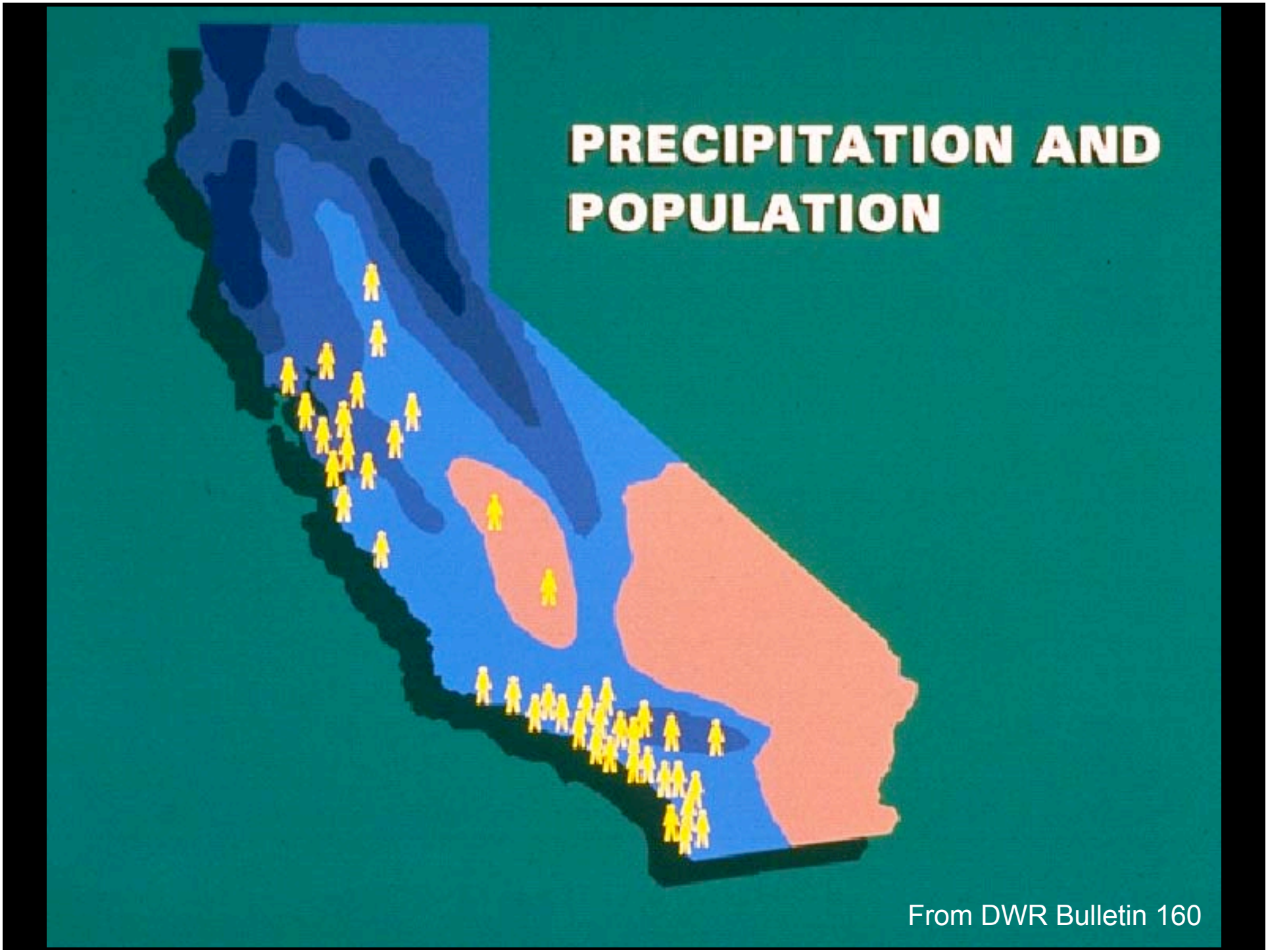
Francis I Chung, Ph.D., P.E.

Climate Scenarios and Projections: the Known, the Unknown, and the Unknowable as Applied to California

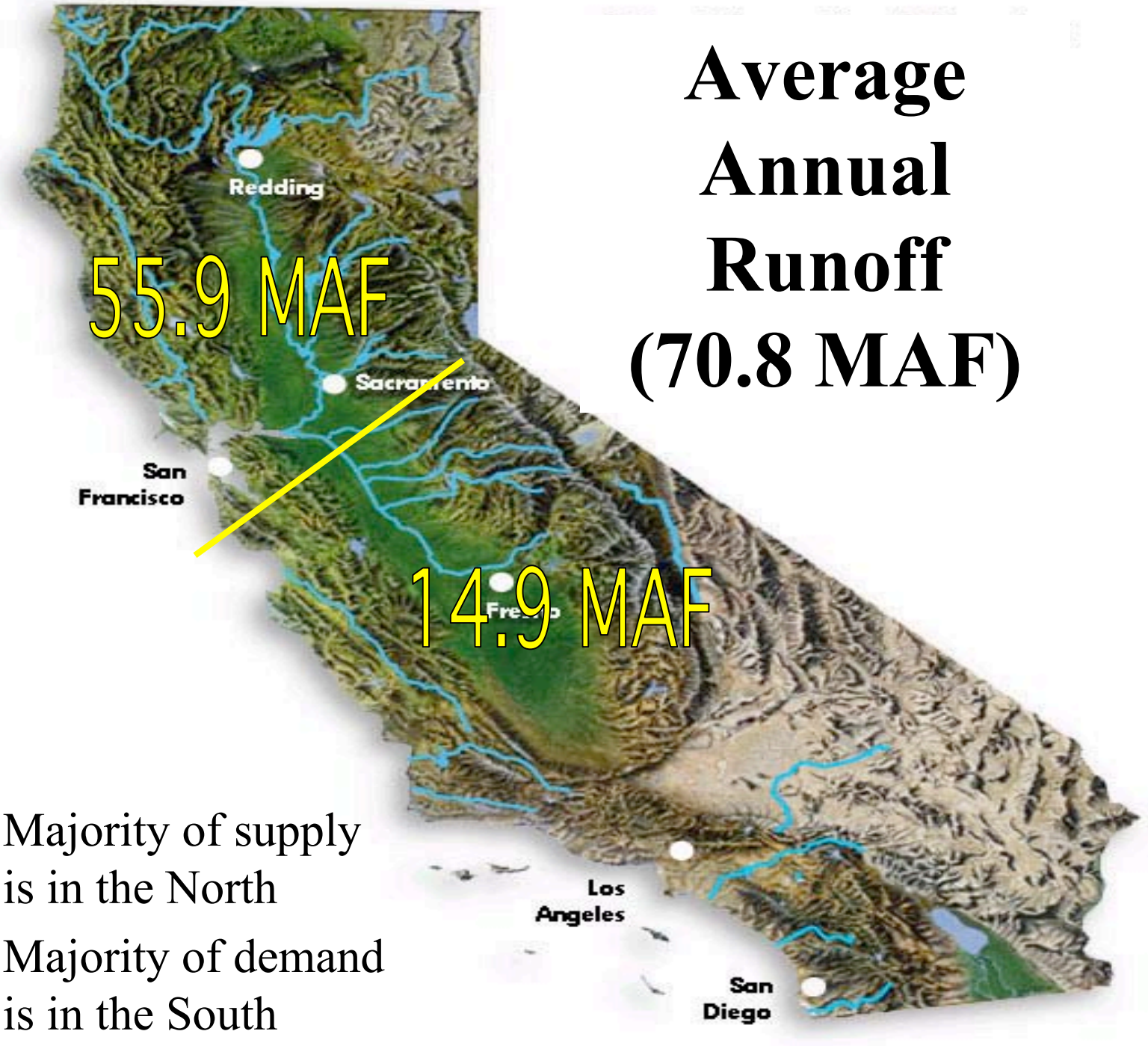
March 11-14, 2004, Aspen Colorado

Modeling Support Branch
Bay Delta Office

California's Water Resources


PRECIPITATION AND
POPULATION
From DWR Bulletin 160

Average Annual Runoff (70.8 MAF)

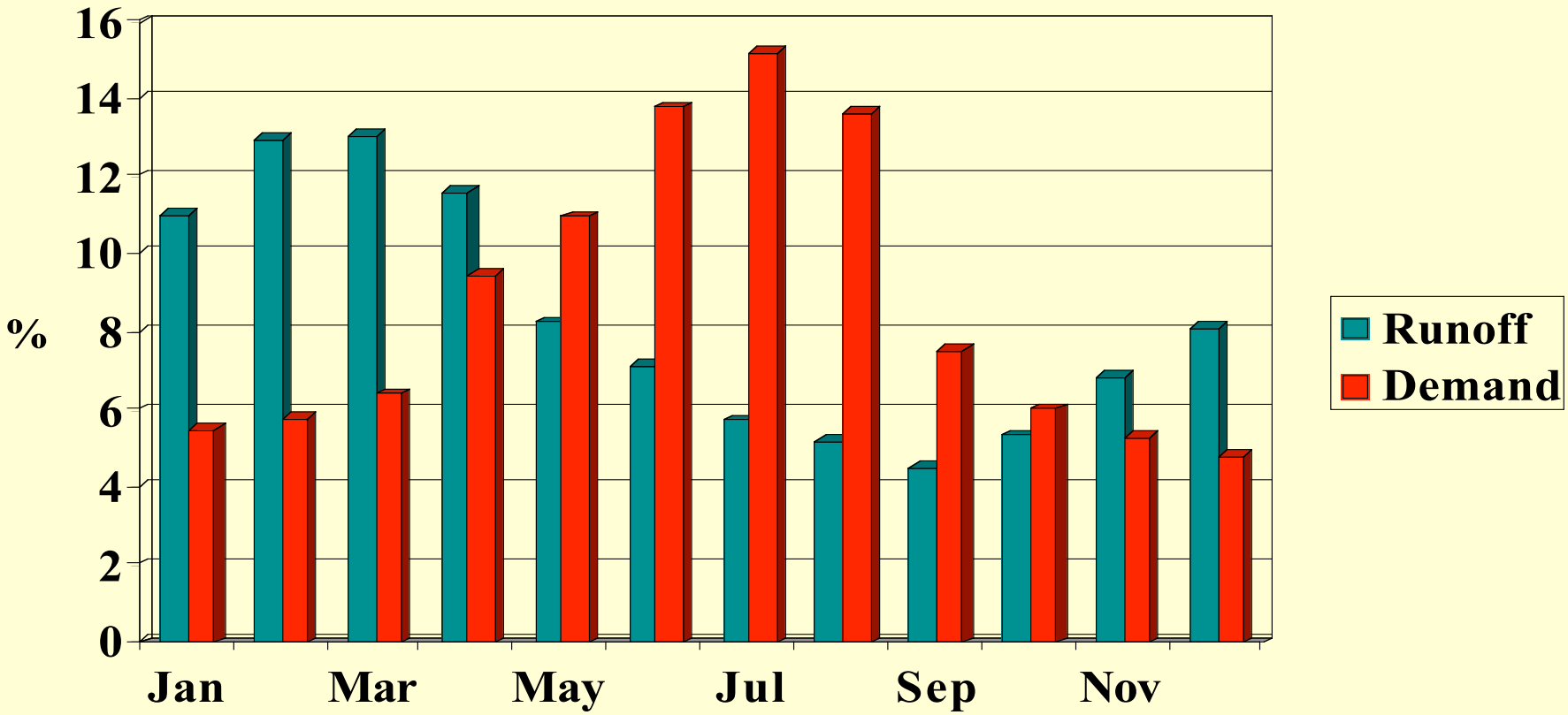


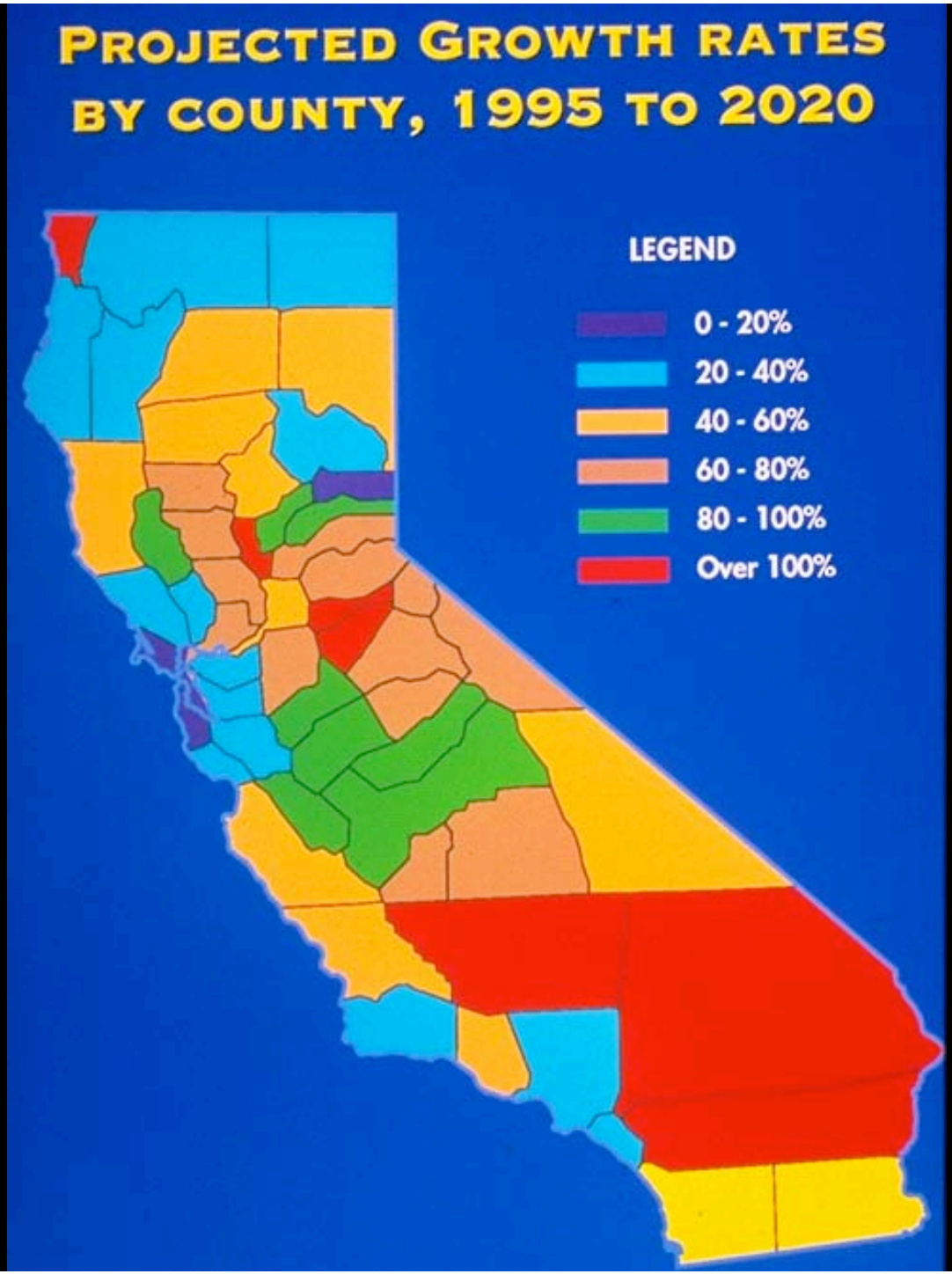
Majority of supply is in the North

Majority of demand is in the South

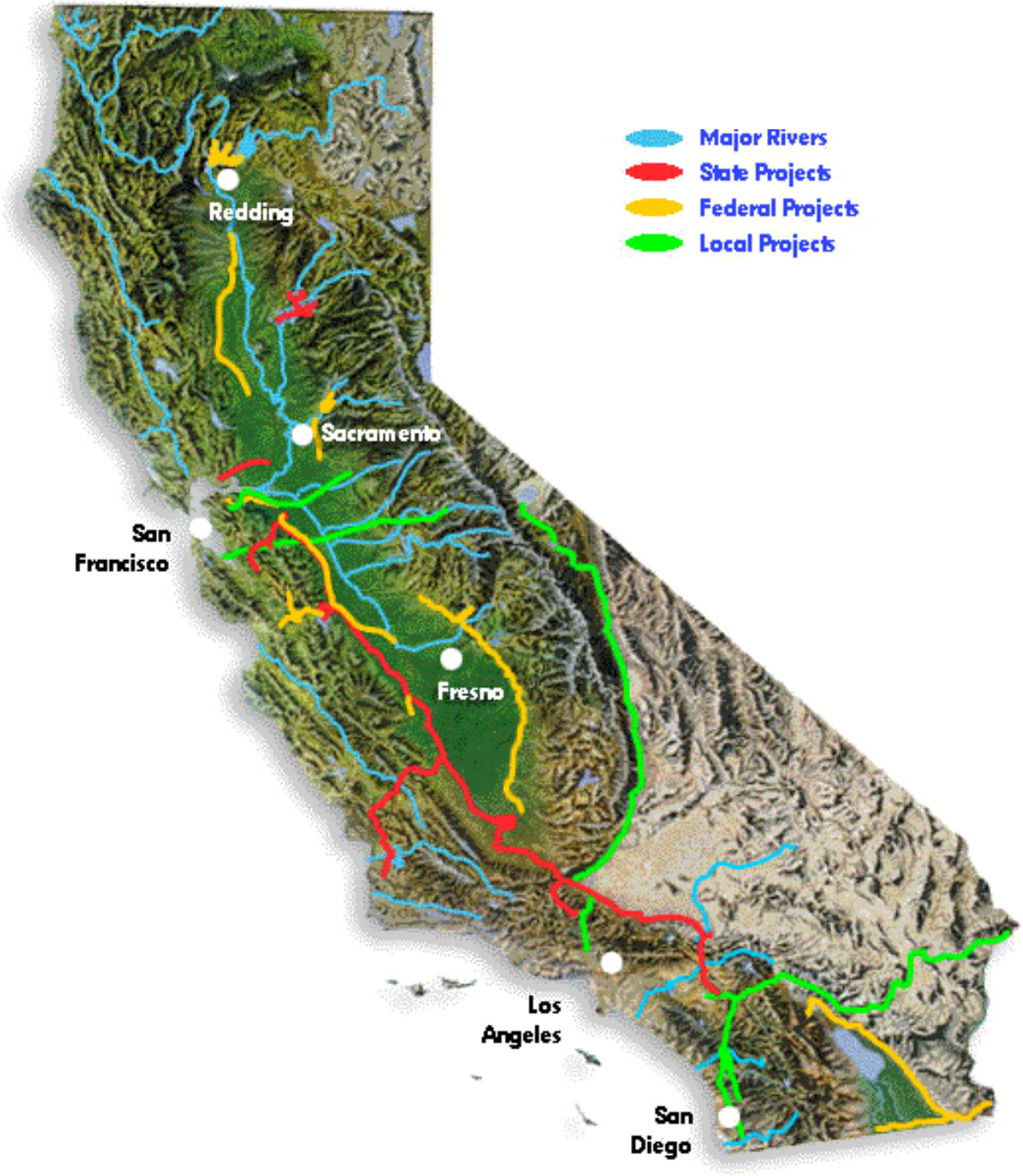
Seasonal Mismatch of Supply and Demand

- Runoff is greatest in the winter/spring
- Demand is greatest in the summer





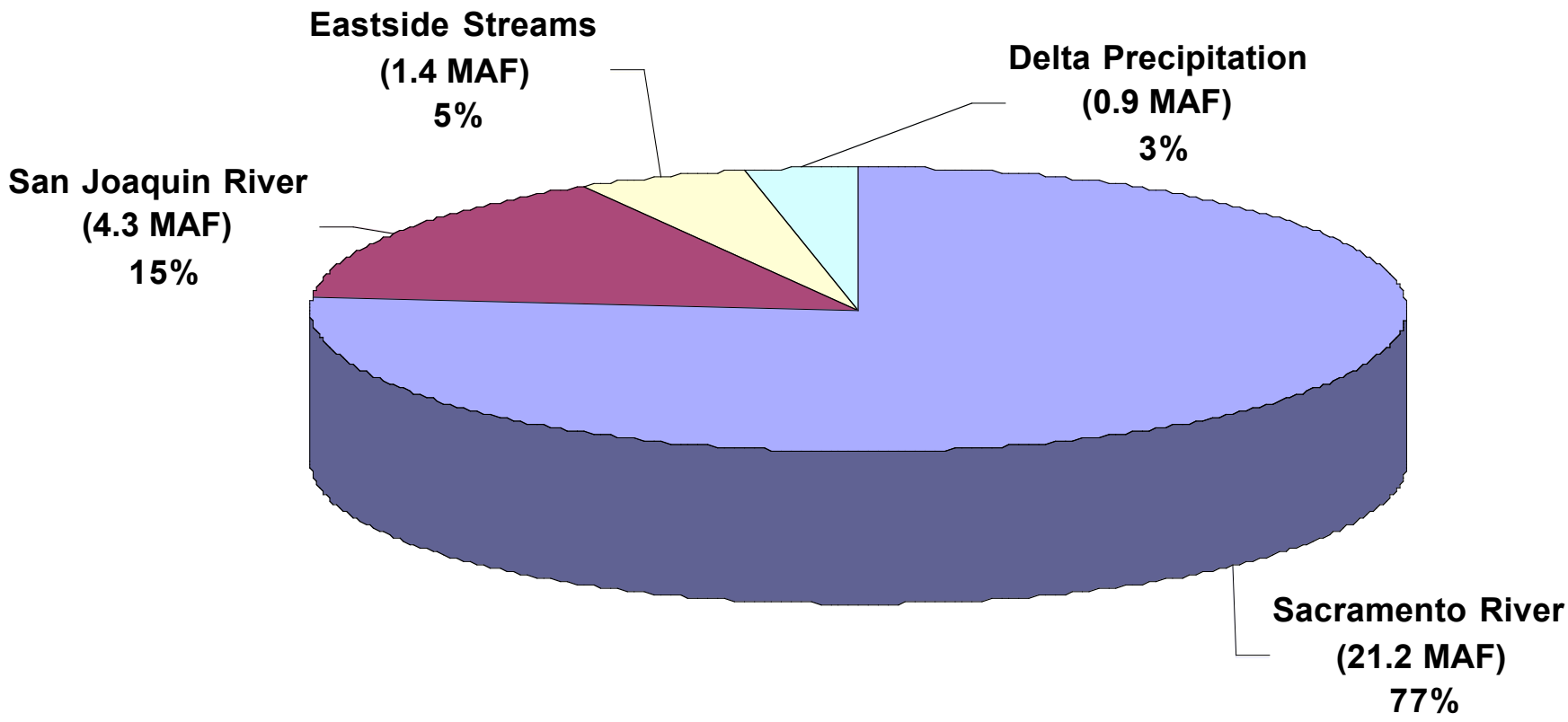
From DWR Bulletin 160


Major Rivers
State Projects
Federal Projects
Local Projects
Redding
Sacramento
San Francisco
Fresno
Los Angeles
San Diego

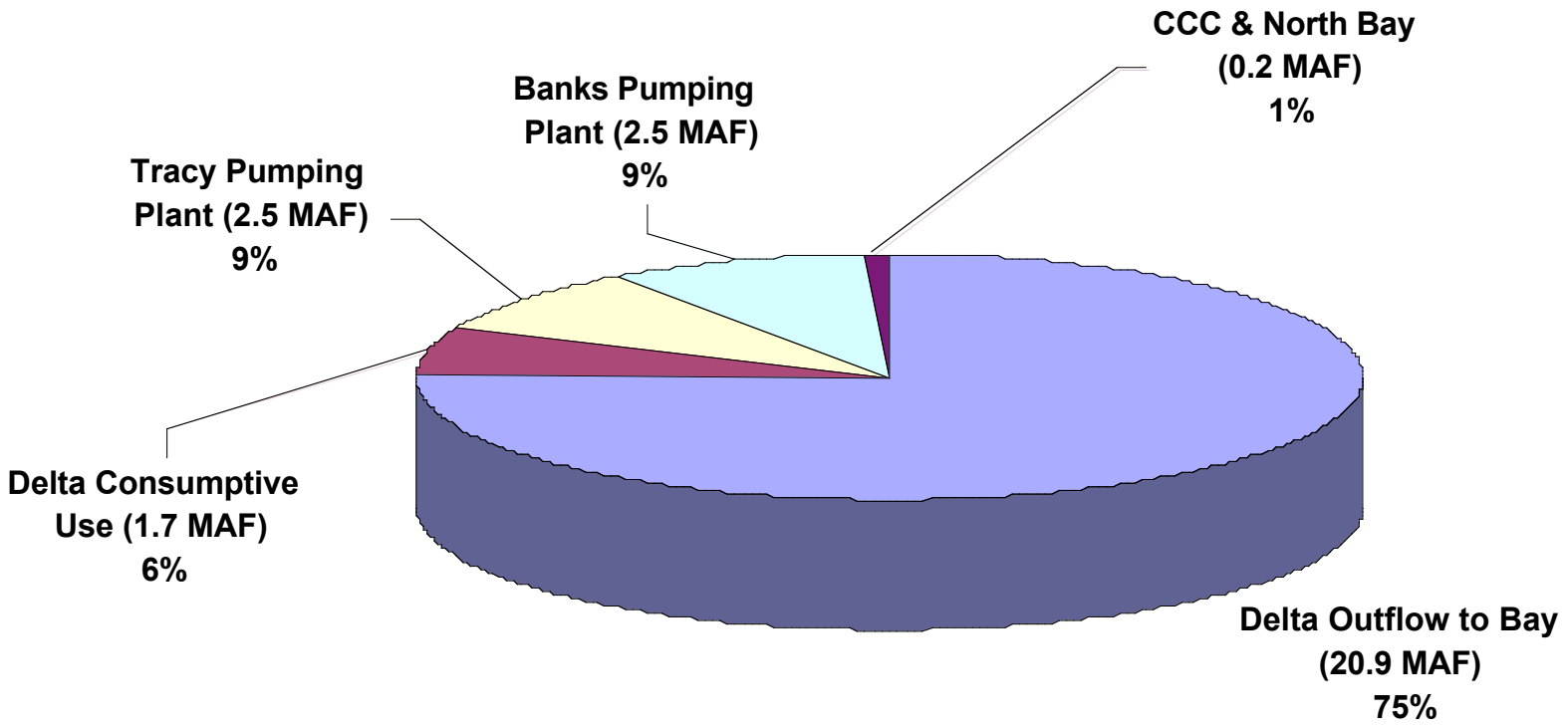
Bay-Delta System

Bay-Delta detail image from CALFED

Sacramento - San Joaquin Delta
Average Annual Inflow
(27.8 MAF)



Sacramento - San Joaquin Delta
Average Annual Outflows & Diversions
(27.8 MAF)



Water Resources Management Tools

CALSIM

CALifornia SIMulation Model

California statewide water operations optimization model

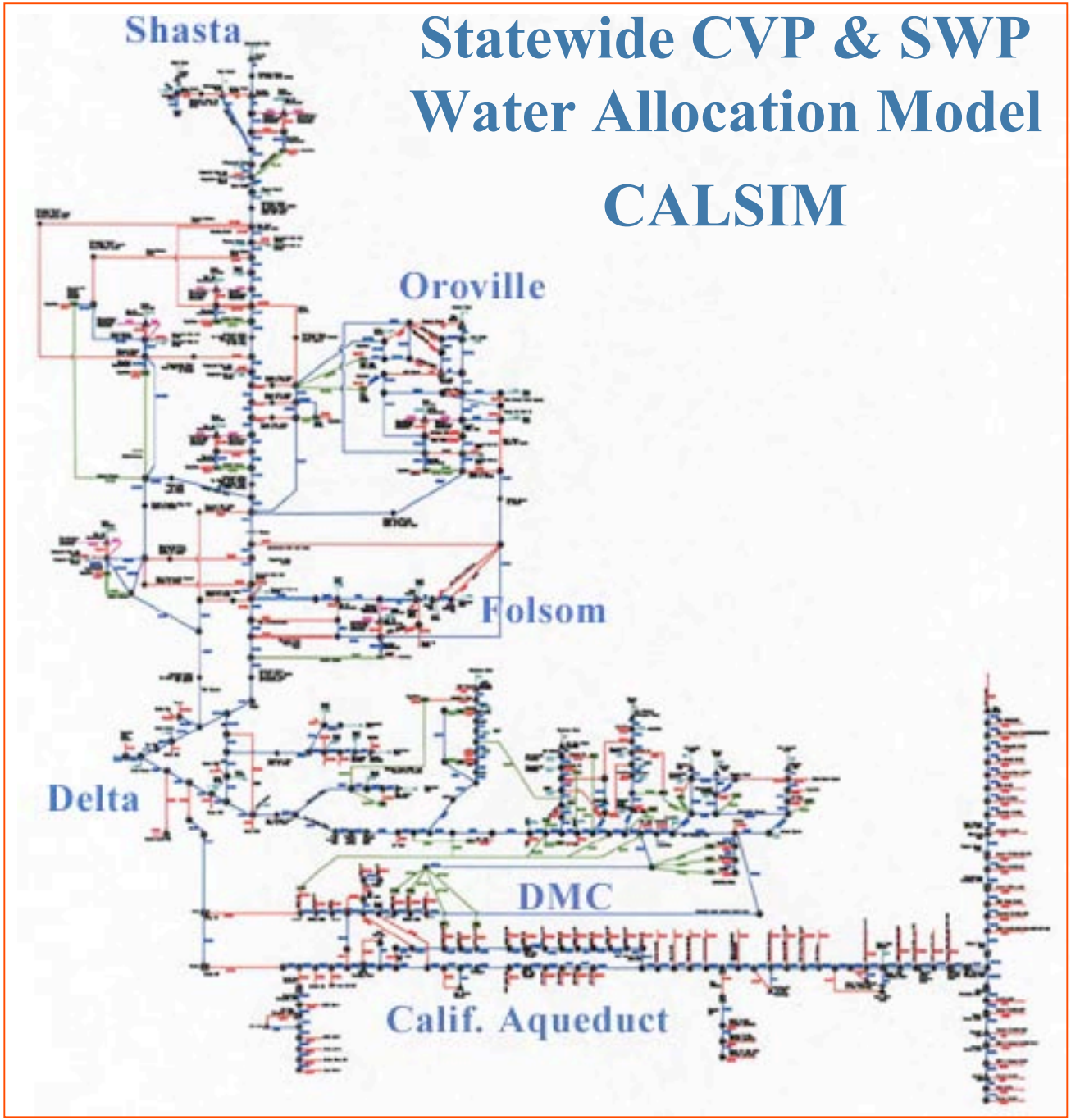
Statewide CVP & SWP Water Allocation Model

CALSIM

State Water Project

Central Valley Project (Federal)

Local

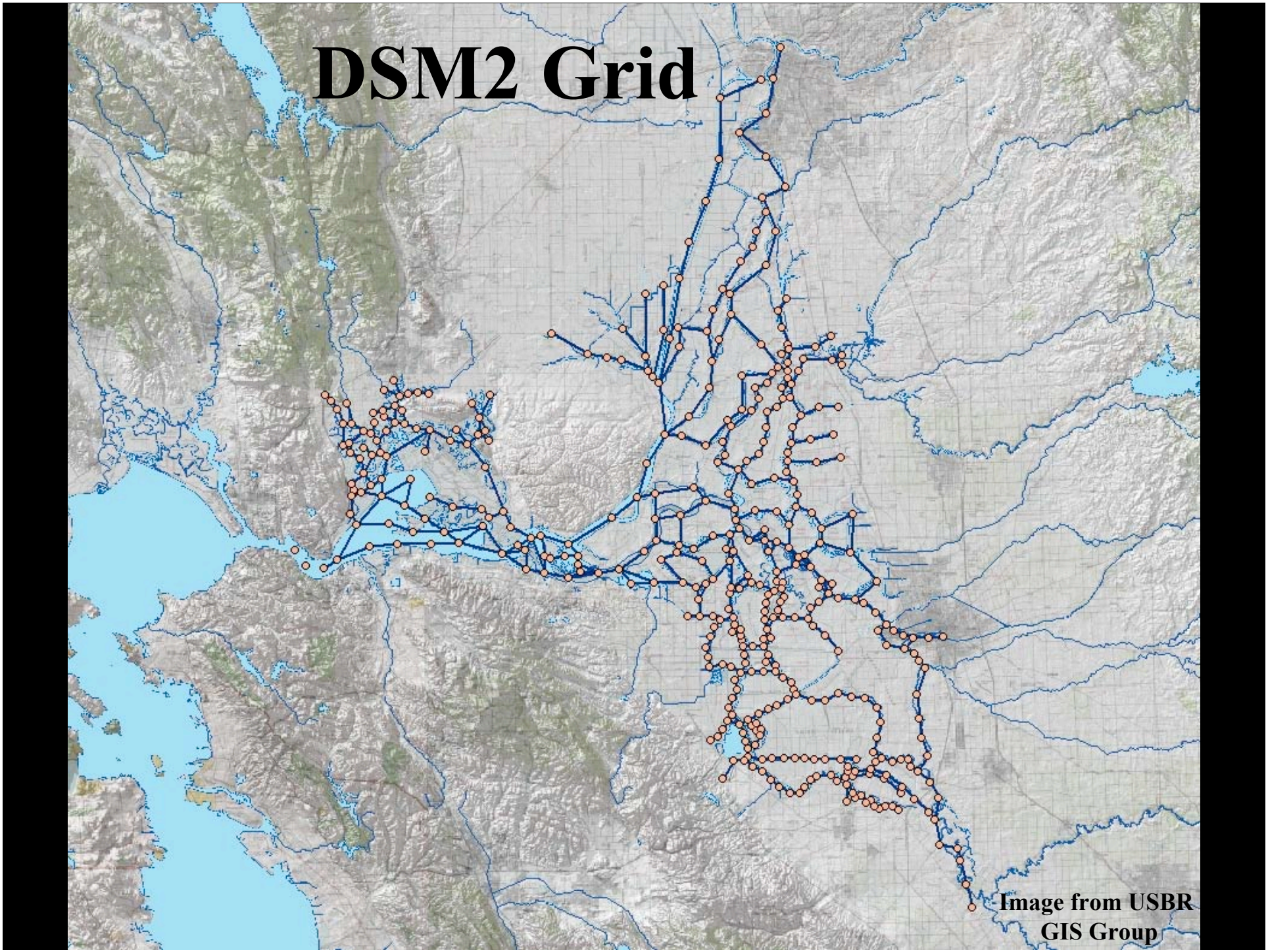


DSM2

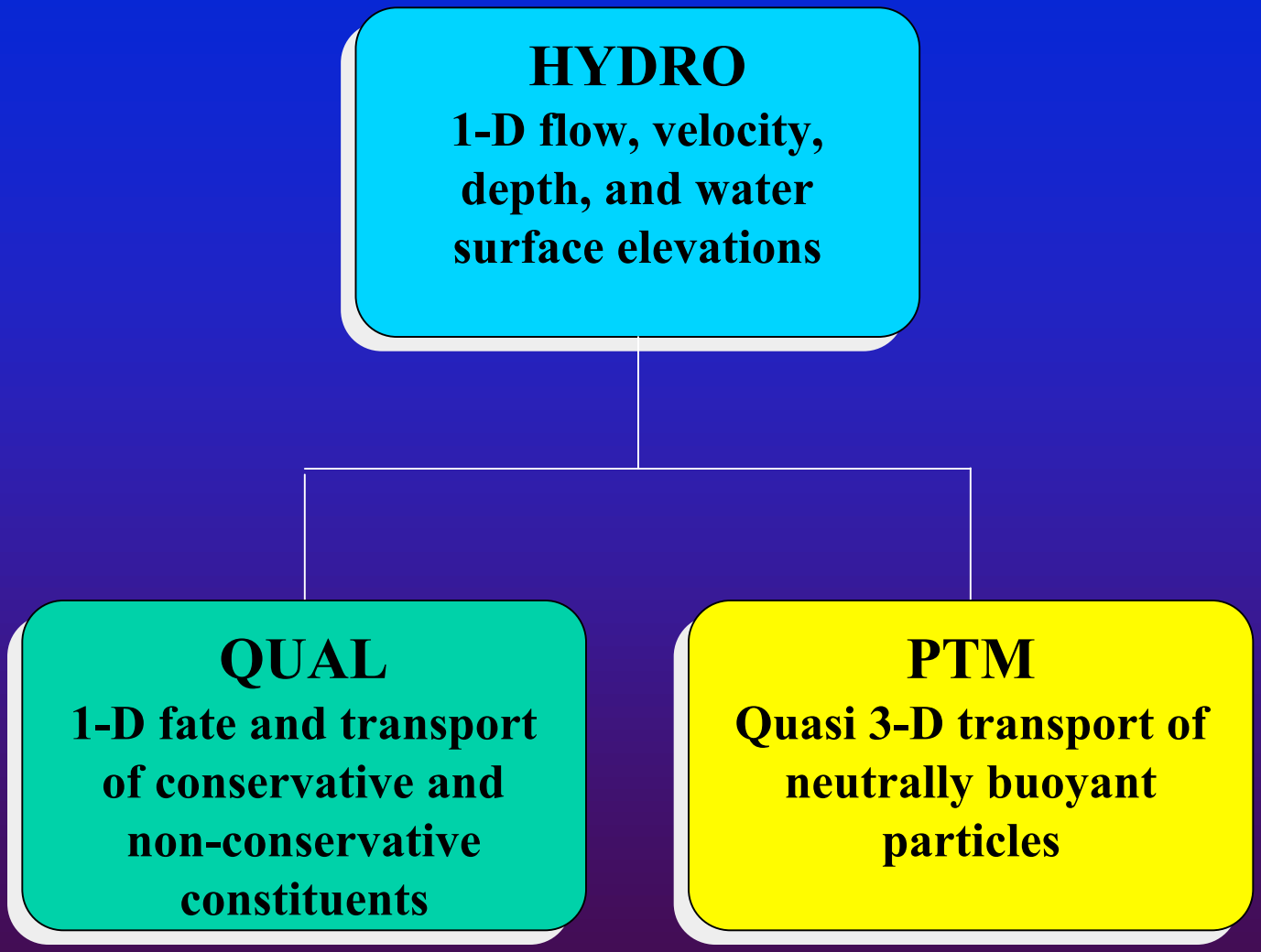
Delta Simulation Model 2

One-dimensional hydrodynamics and water quality in channel networks

DSM2 Grid



DSM2: Delta Simulation Model 2

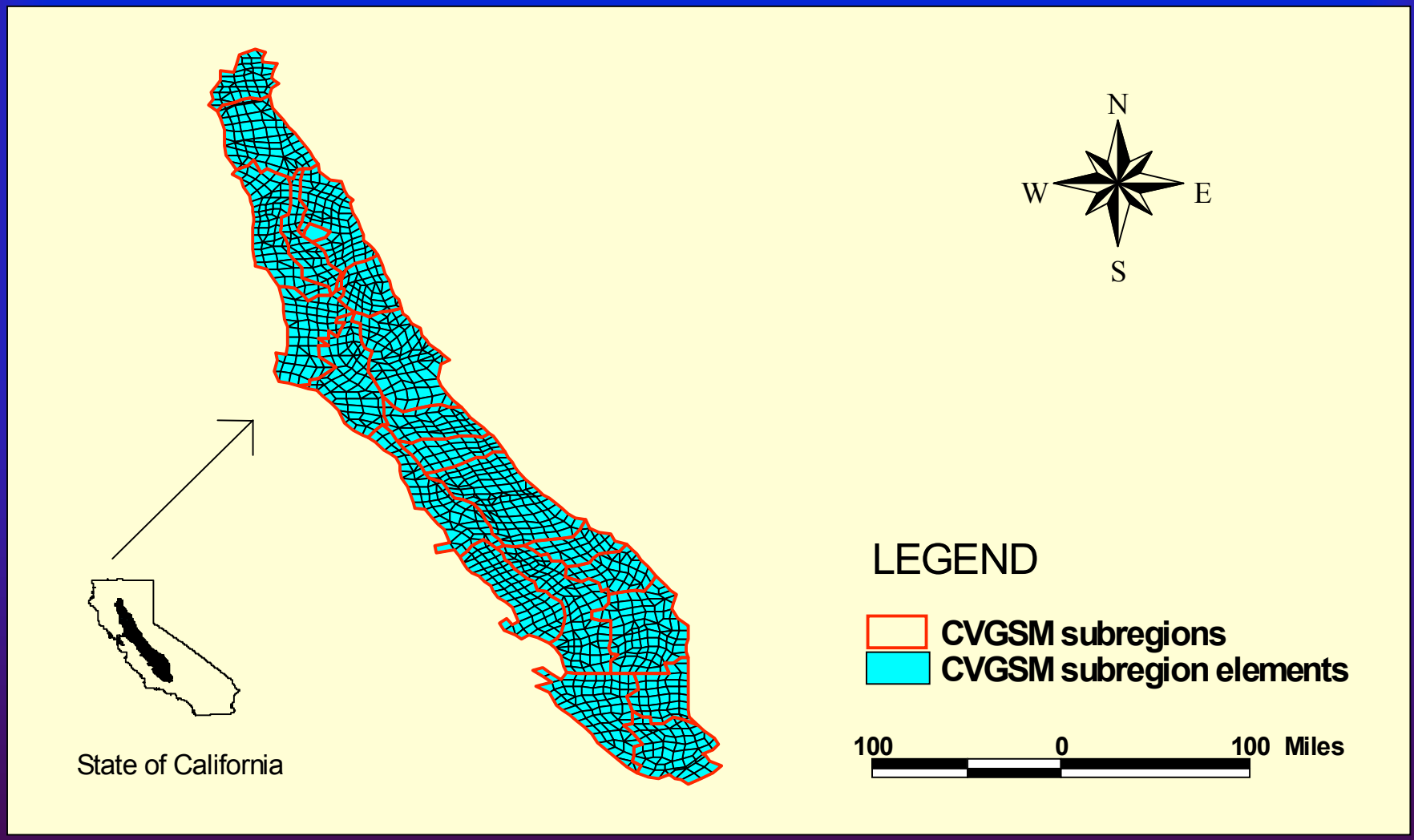


IGSM2

Integrated Groundwater and Surface water Model 2

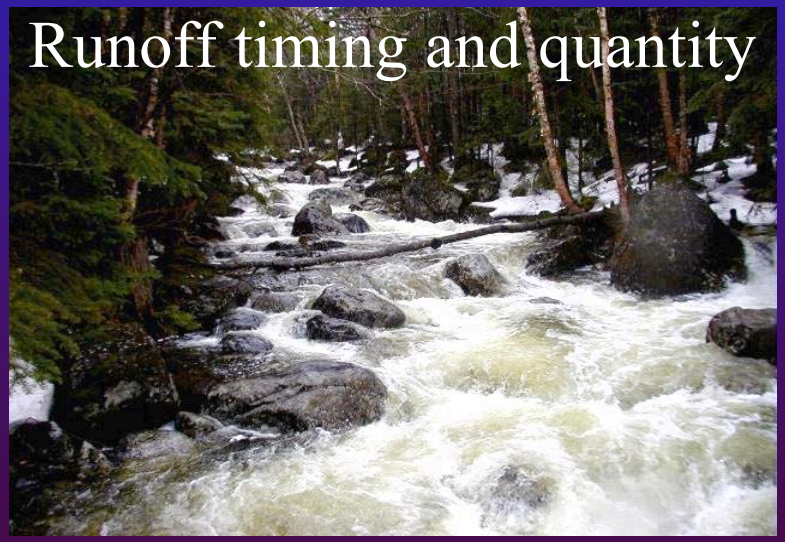
Quasi 3-dimensional groundwater and 1-dimensional surface water model

CVGSM Subregions



Climate Change Impacts on Water Resources

Potential Impacts of Climate Change



Floods and Droughts

- Frequency
- Magnitude
- Duration

Water Supply

- Water Demands
  human and vegetation

- Inflows to Reservoirs
  amount and timing
- System Operations
  size and timing of flood control space; reliability of supplies

Water Quality

- Drinking WQ

- Environmental WQ
  River and lake temperatures
  In-stream flow requirements

San Francisco Bay-Delta

- Levee Stability (flooding or sea level rise)
- Sea Water Intrusion

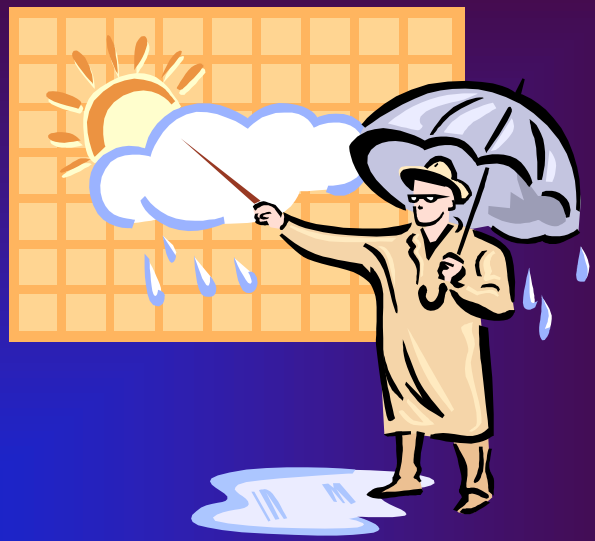
Joint DWR-USBR Climate Change Team

GOAL

Provide qualitative and quantitative estimates of effects of climate change on California's water resources

Provide information that is relevant to water resources decision makers including assessment of risks

Climate modelers forecast possible future climate conditions



Our climate change team assesses potential impacts that those climate change scenarios could have on California's water resources

Potential Collaborators

California Energy Commission

Lawrence Berkeley Lab

DWR

Lawrence Livermore Lab

SCRIPPS Institute of Oceanography

U.S. Geological Survey

U.S. Bureau of Reclamation

UC Davis Civil Engineering

Climate Change Team Work Plan

Select climate change scenarios

Investigate water supply impacts of hydrology changes

Investigate local impacts of sea level rise on the Delta

Assess combined impacts of changed hydrology and sea level rise

Relationship Between Model Outputs

Global Climate Models

Output
- Precipitation
- Snowmelt
- Soil Moisture
- Evapotranspiration
- Temperature

CALSIM

Output
- Reservoir operations
- Project deliveries
- Delta inflows and exports

DSM2

Output
- Flow
- Stage (water level)
- Salinity
- Other water quality constituents

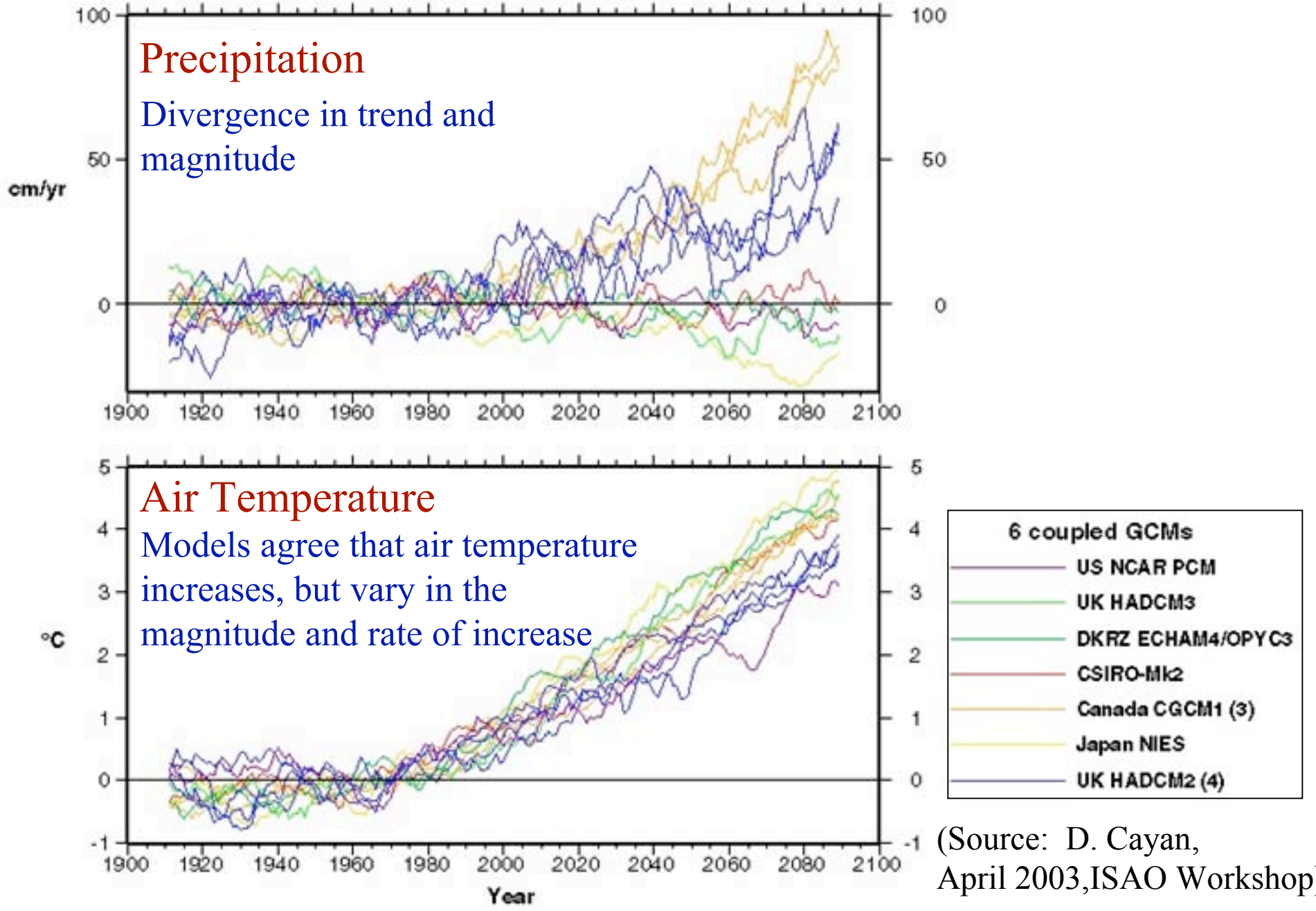
Outputs shaded blue provide input to the next model.

Challenge

Given the variability and uncertainty in climate projections over California,

how do we apply climate change impacts assessment to planning and management of California's water resources?

Climate Change Predictions for Northern California Differ



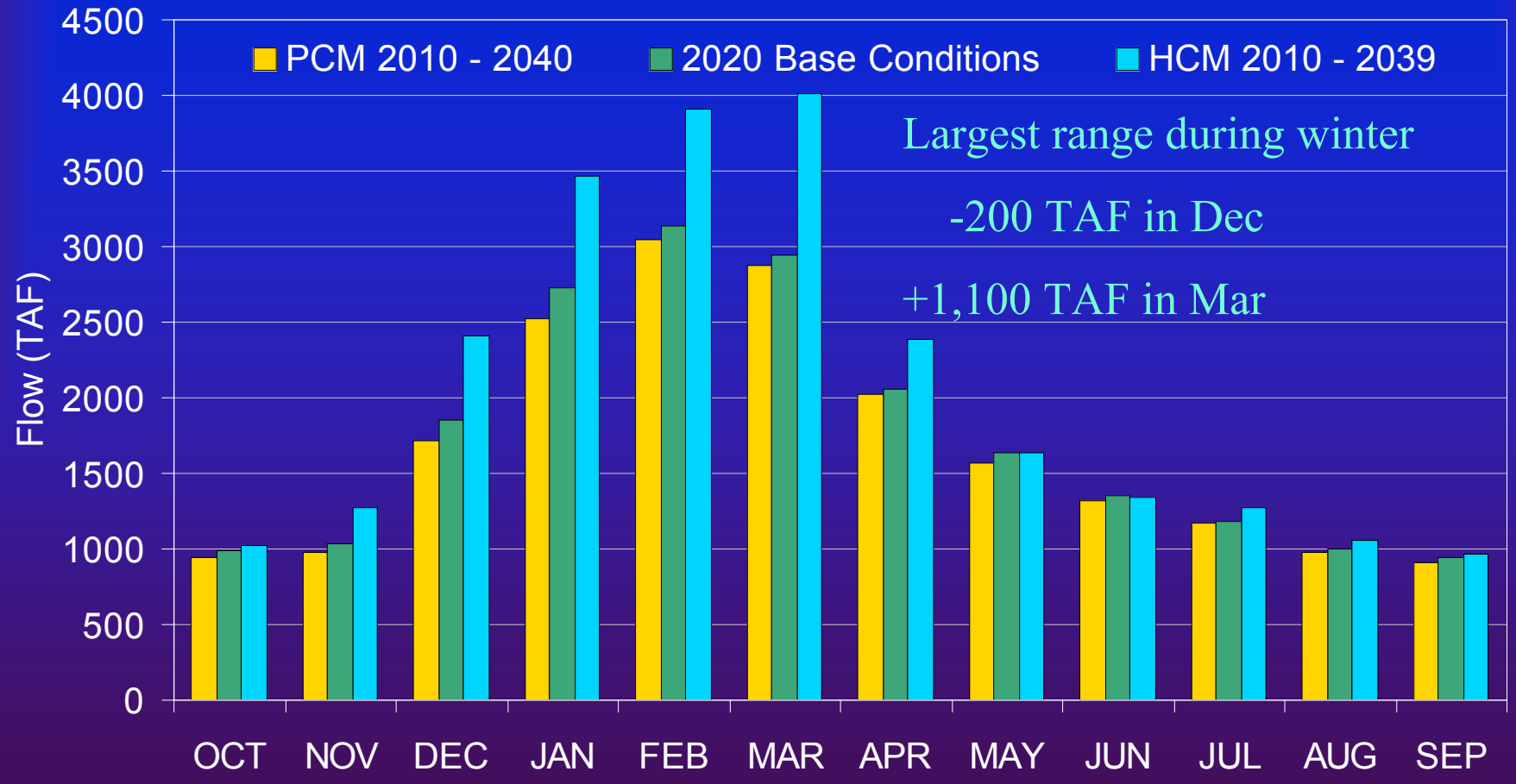
(Source: D. Cayan, April 2003,ISAO Workshop)

Initial Climate Change Investigations

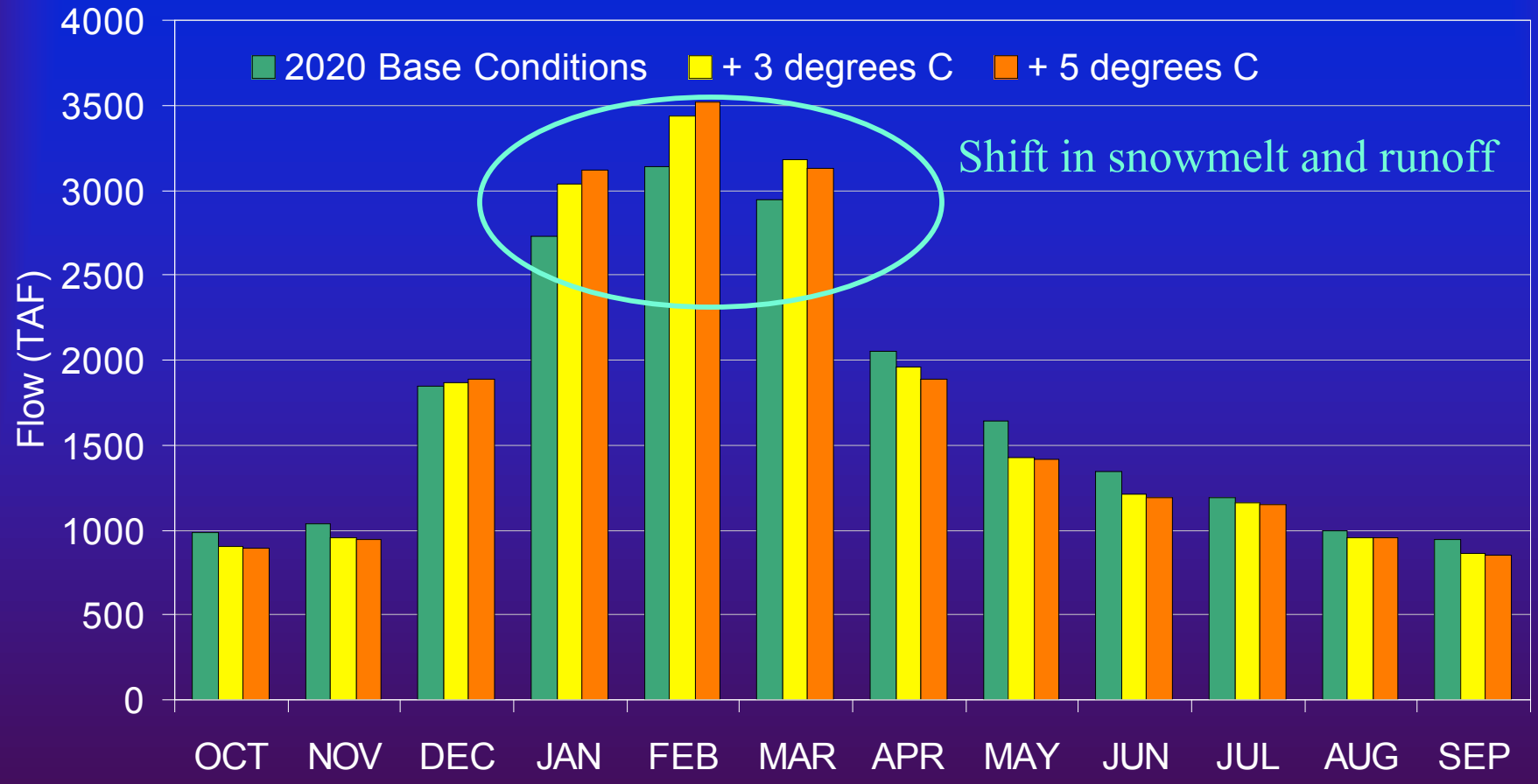
- Bookend approach
  - A lot warmer and wetter
    (HadCM2 2010-2039 +1.4°C and +26.4% precip)
  - A little bit warmer and drier
    (PCM 2010-2039 +0.4°C and -2.3% precip)
- Focus on predictions with least uncertainty
  - Increase air temperature only (1.5°C, 3°C, 5°C)
  - Sea level rise
- Challenge is to assign probabilities to each scenario, e.g. assume that each bookend or sensitivity range is equally likely

Preliminary Simulation Results

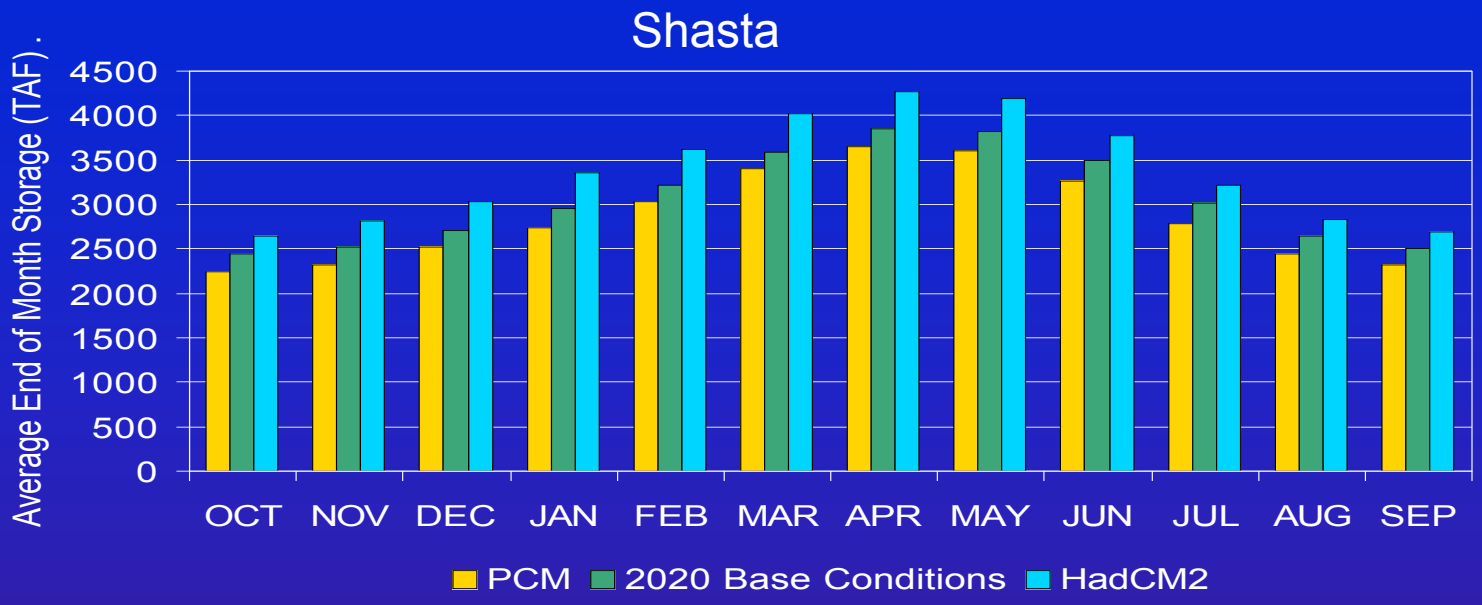
Delta Inflow wy1922-1994 Bookend Approach

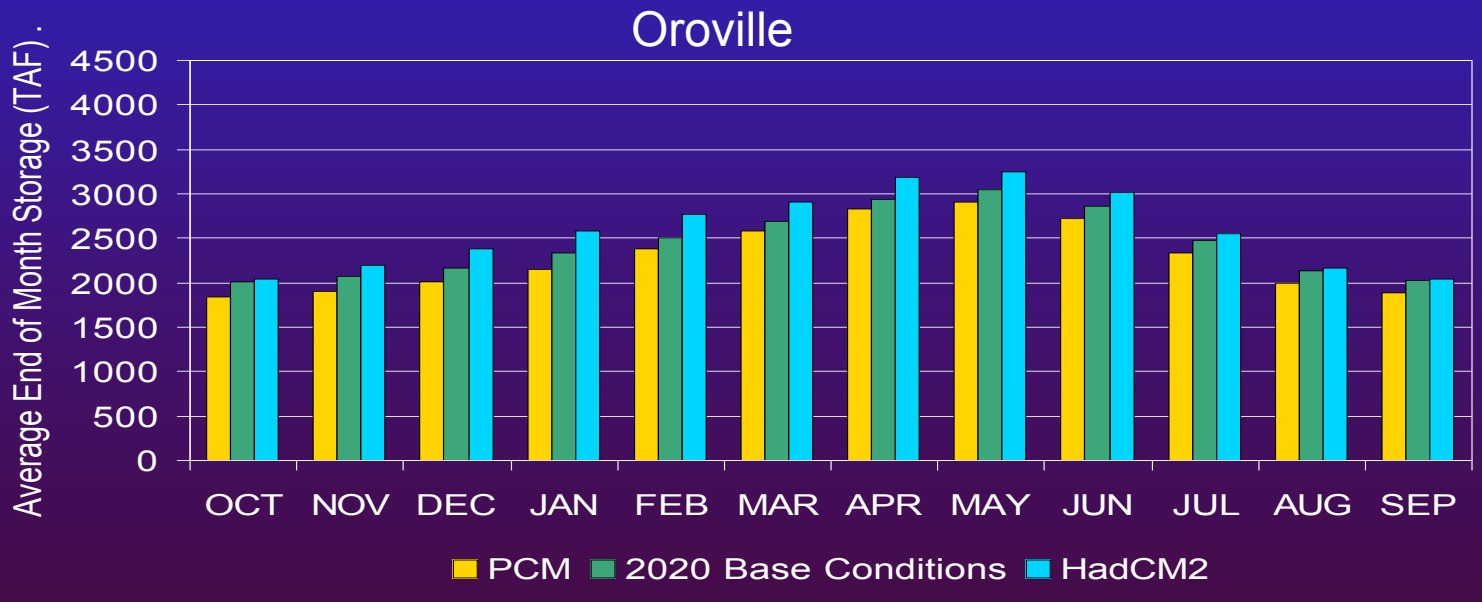


Delta Inflow wy1922-1994 Sensitivity Analysis



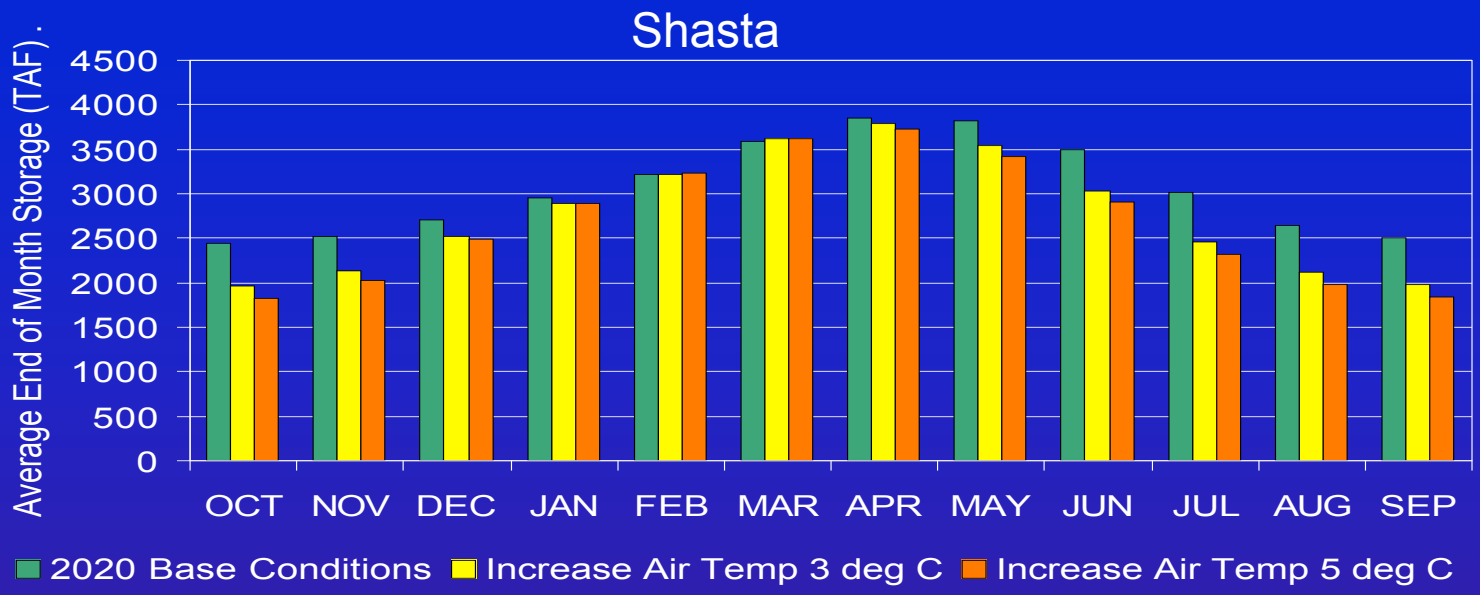
Reservoir Storage: Benchmark

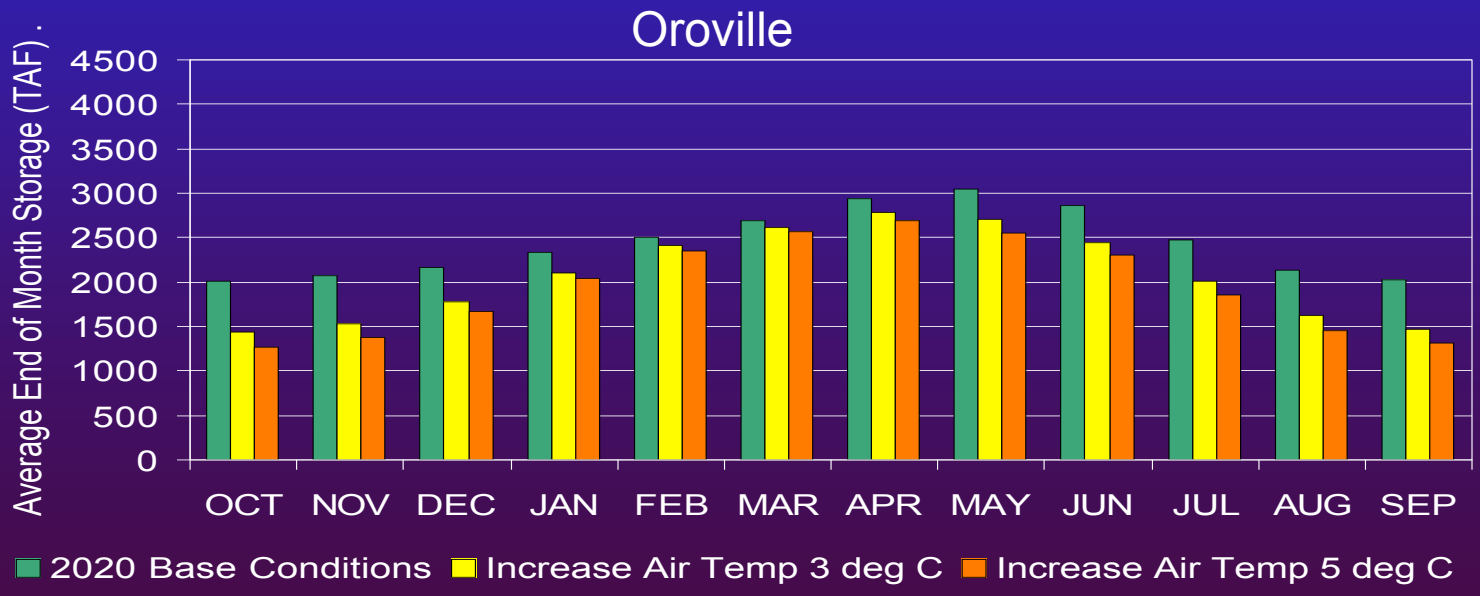




Results are average values for wy1922-1994

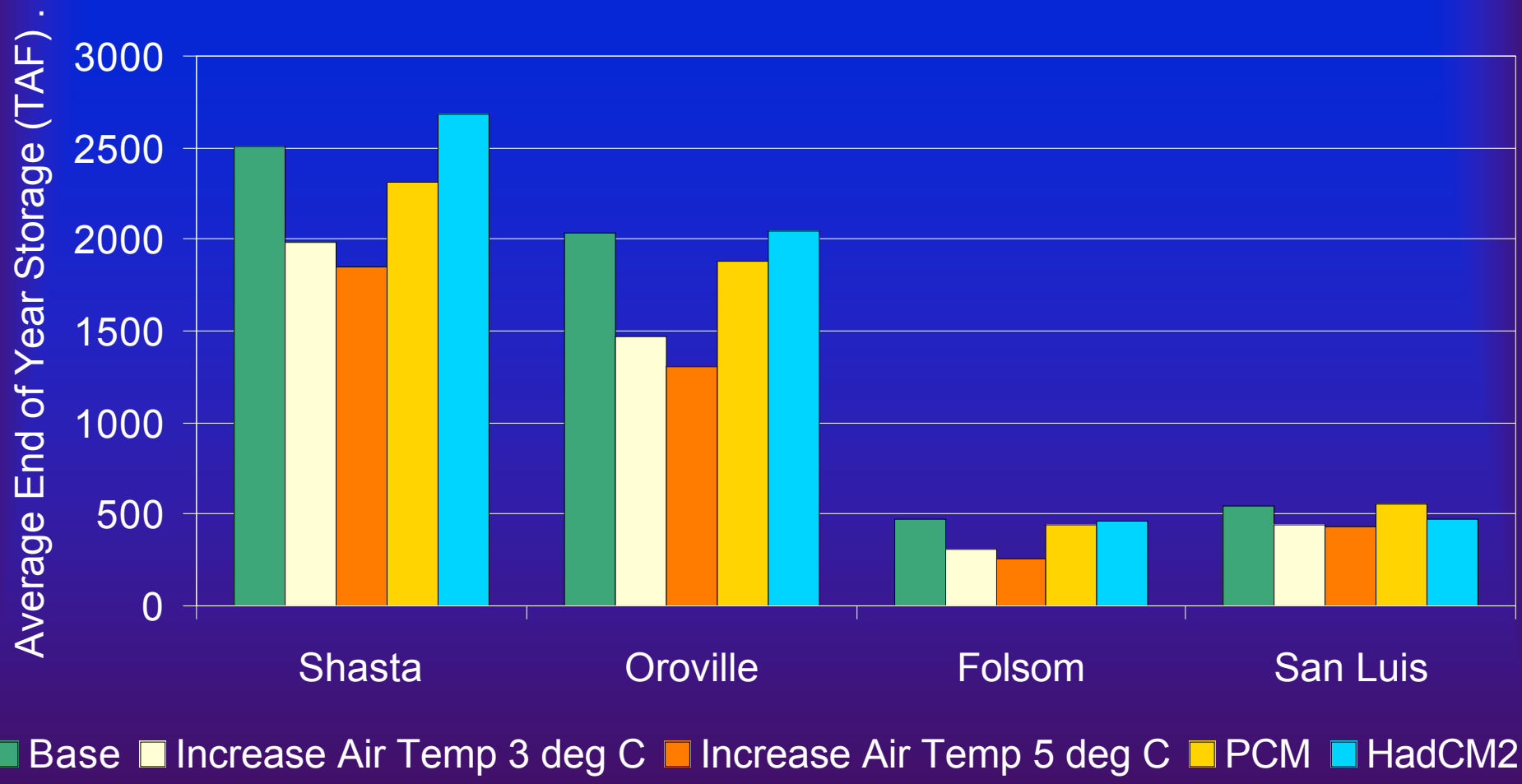
Reservoir Storage: Sensitivity Analysis





Results are average values for wy1922-1994

End of Year Reservoir Storage



Results are average values for wy1922-1994

Risk Assessment

Risk =

f(Event, Consequences, Probability)

Characterizing Climate Change Uncertainty

- Seek advice from other experts
- Develop/apply techniques for quantifying the uncertainty in climate change predictions
- Bookend approach
  - A lot warmer and wetter
  - A little bit warmer and drier
- Focus on predictions with least uncertainty
  - Increase air temperature only
  - Sea level rise

Risk Assessment

- The bookend and sensitivity analysis approaches provide ranges of consequences for assumed events
- Without assuming probabilities for the events
  - Risk assessment has yet to be conducted
  - Management choices have not been defined
- Uncertainty analysis is needed

Climate Change Uncertainty Analysis

- Develop monthly sensitivity patterns for:
  - Air temperature
  - Precipitation
  - Natural runoff
- Watershed scales (e.g. Oroville, Shasta, etc)
- Evaluated at projection milestones (e.g. 25 years out, 50 years out)
- Account for projection uncertainty:
  - Patterns from multiple CO_2 increase scenarios and/or multiple GCMs of each CO_2 scenario

Goals of Climate Change Risk Assessment

- Determine probabilities and potential impacts of incremental climate change on California's water resources
- Risk information can be used to:
  - Develop management plans
  - Determine priorities in resource allocation
  - Develop mitigation measures
- Better information on climate change projection uncertainty is needed to conduct this type of risk assessment

Contact Information

Francis Chung, Ph.D., P.E.

chung@water.ca.gov

916-653-5924

http://modeling.water.ca.gov