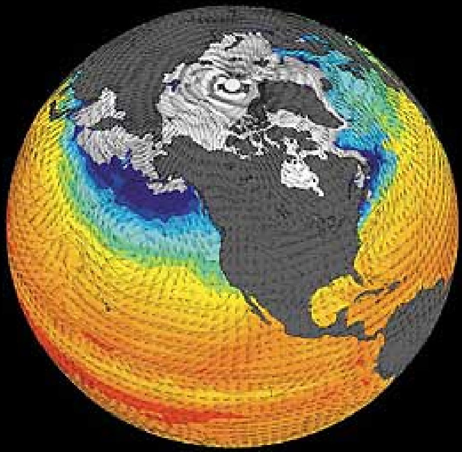
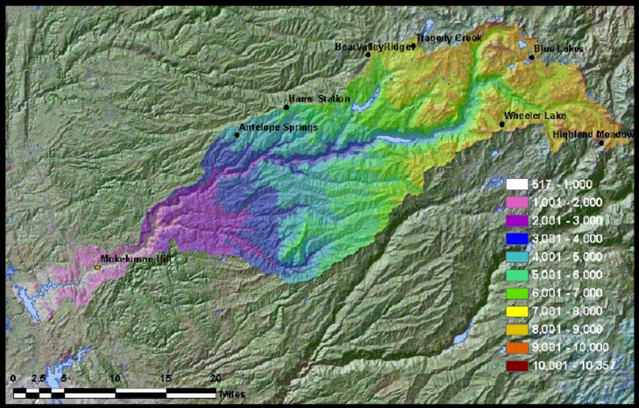
Climate Change and Water Supply Planning
Understanding Current Technology

Case Study: East Bay Municipal Utility District





Aaron Hope

November, 2008

EDAW | AECOM RMC EBMUD

A Collaborative Project

East Bay Municipal Utility District

www.ebmud.com/

RMC Water and Environment

www.rmcwater.com

EDAW / AECOM

www.edaw.com

Stockholm Environment Institute

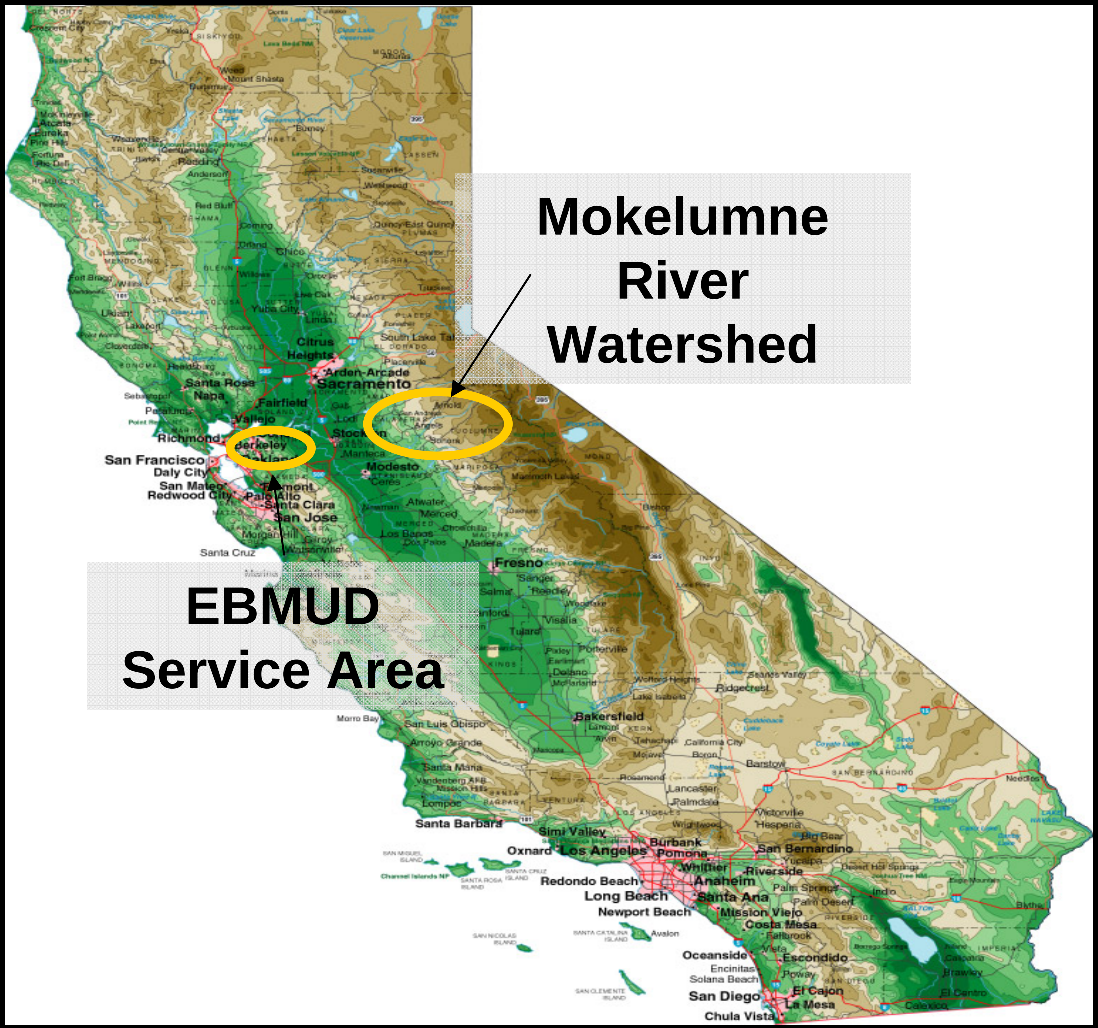
www.weap21.org
www.sei.se

Climate Change and Water Supply Planning

Purpose of this presentation:

- EBMUD Water Supply Management Program
  - Define the need for additional water supplies to meet demand through 2040
  - Understand climate change implications
- How could water supply be affected?
- What do we know so far?
- What tools are available to water managers?
- Which approach is appropriate?

Introduction to EBMUD



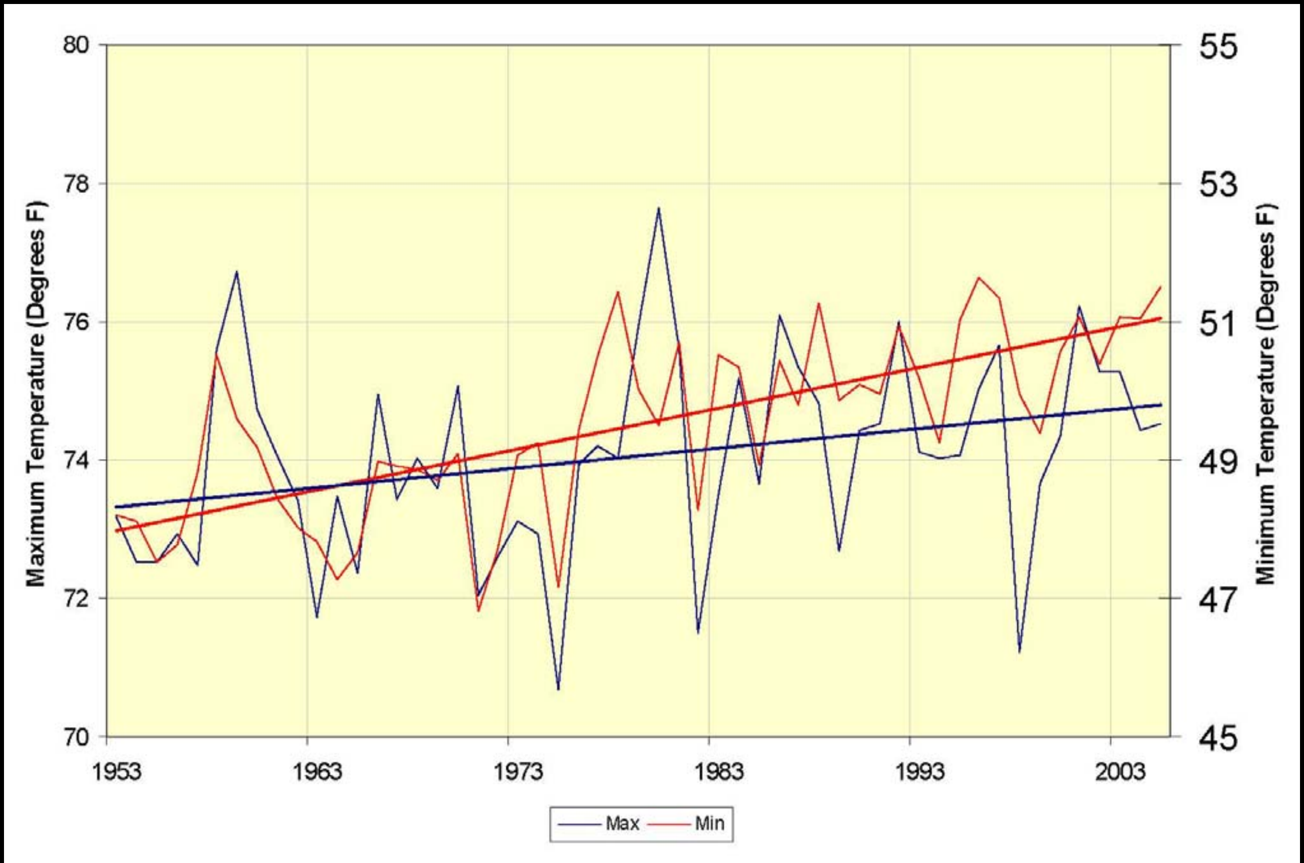
Introduction to EBMUD

- Supplies water to 1.3 million customers
- Primary water source: Mokelumne River, Sierra Nevada
  - Mokelumne provides ~90% of supply
  - Historically, April 1st SWE has constituted over 460 TAF of storage
- Sensitive to climatic variability
  - Severe droughts in historic record, mandatory rationing up to 25%
- Demands expected to increase by over 20% in next 30 years

Warmer Temperatures

- Almost a 2ºC increase between 1950 to present

Min and Max Temperature at Camp Pardee

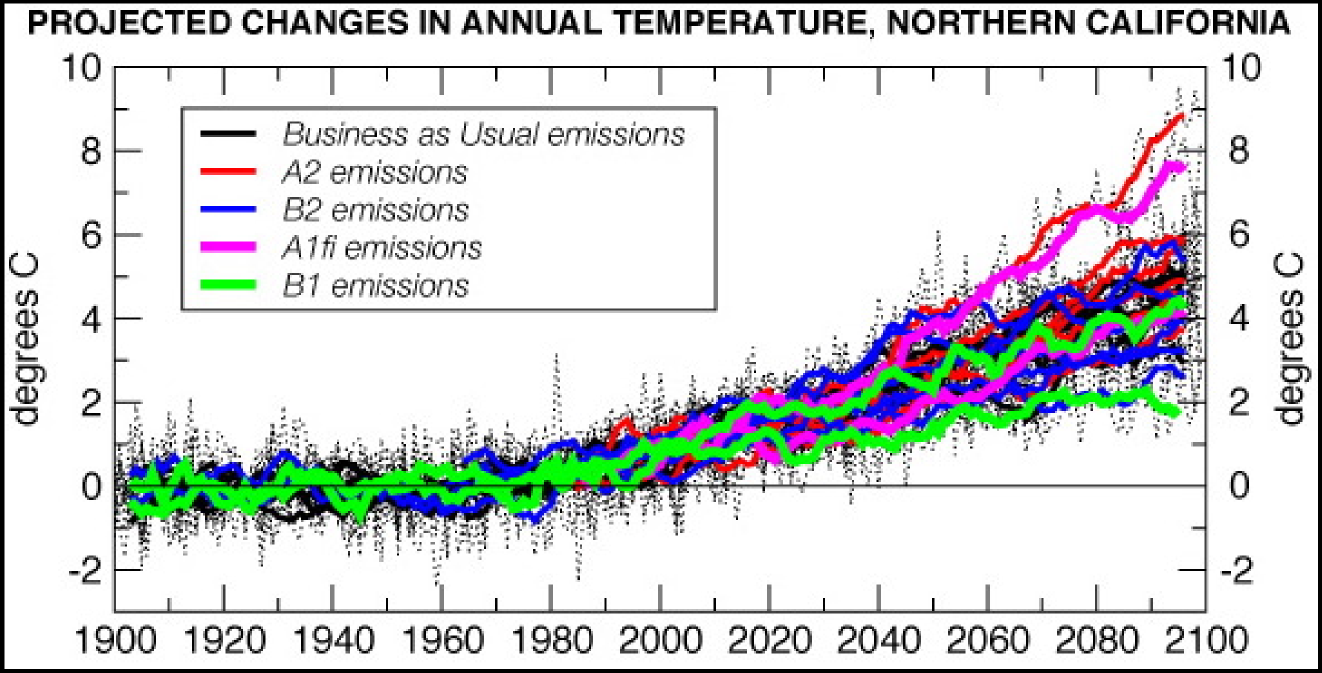


Source: EBMUD

RMC EDAW | AECOM

Warmer Temperatures

- In 2007, the IPCC published likely range between 2.4°C and 6.4°C
- By 2100, most scientists agree on 3°C to 5°C temperature increase in Western US

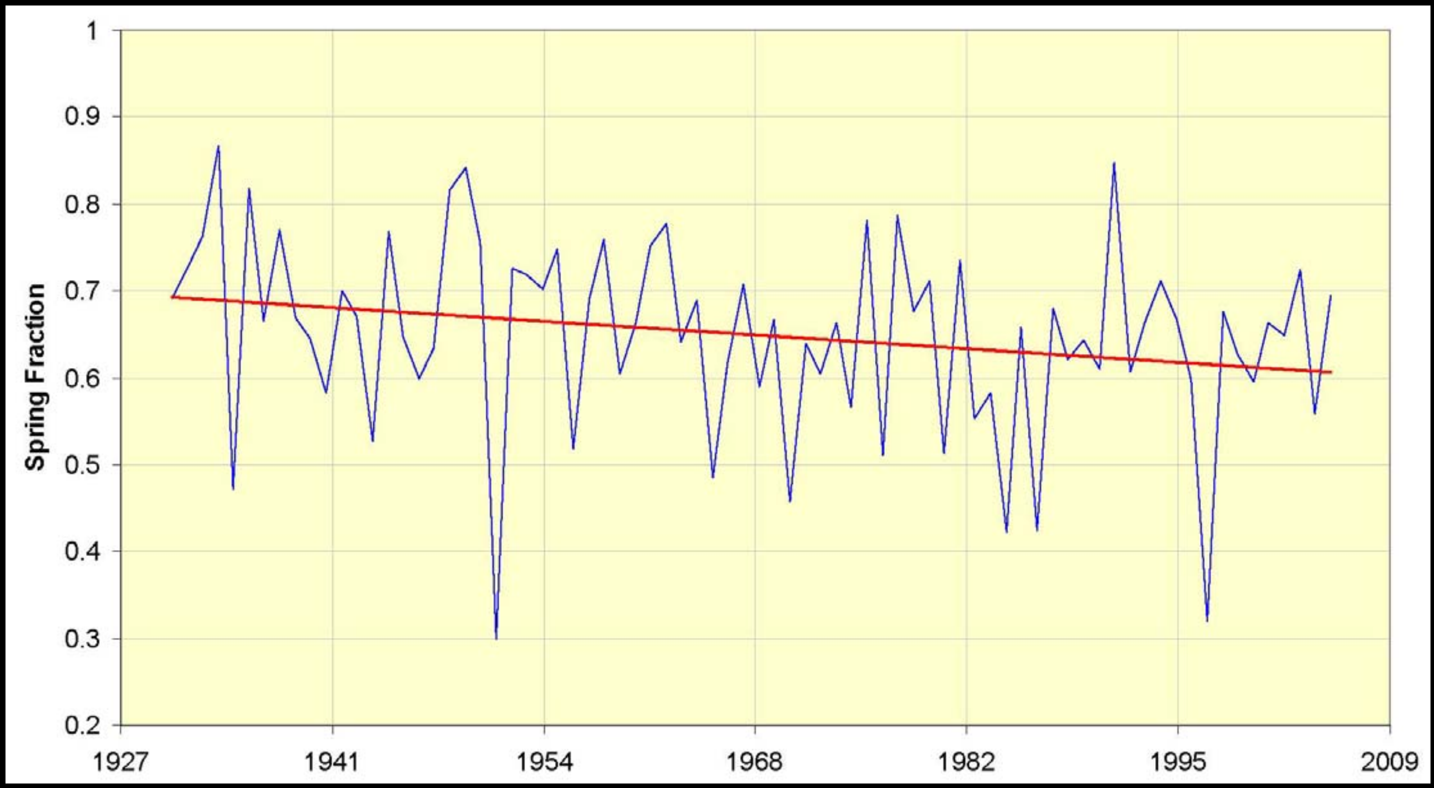


Source: Dettinger, 2005

Changes in Precipitation

- Increase in peak flood flows
- Changes in runoff patterns

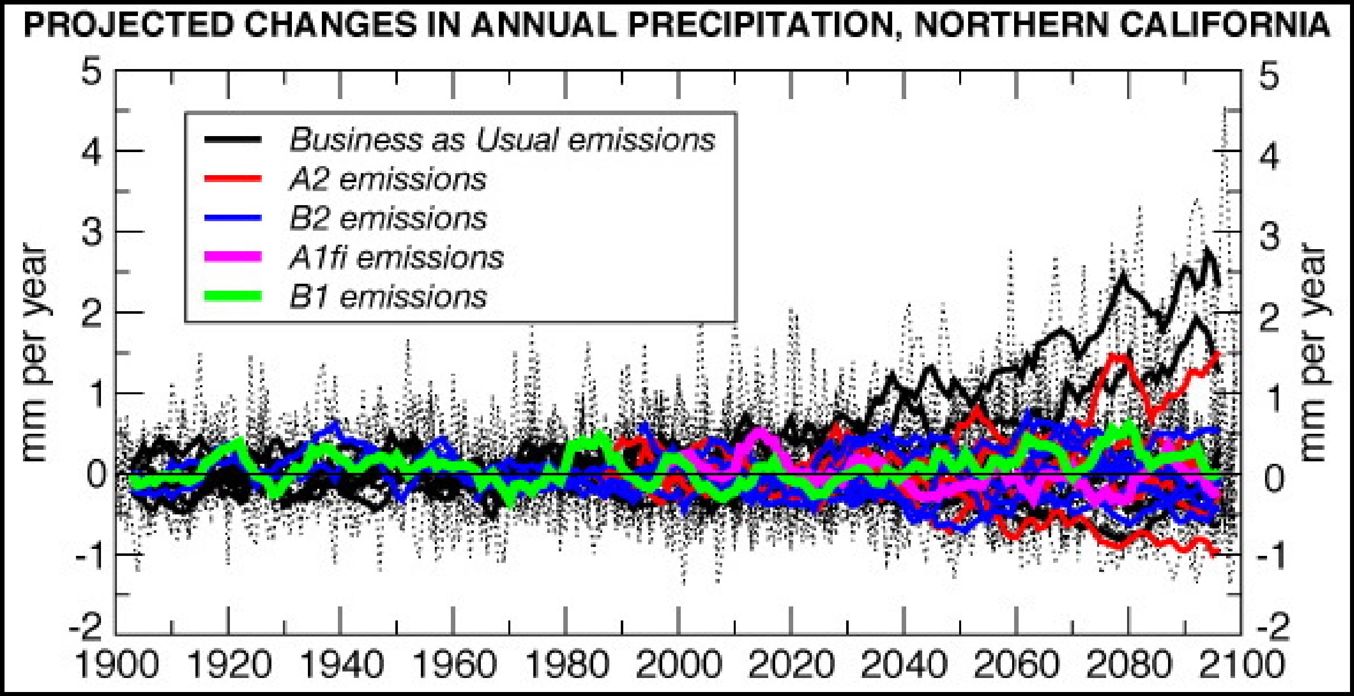
Spring Runoff Fraction of Overall Runoff at Pardee



Source: EBMUD

Changes in Precipitation

- Projections for precipitation less resolute
- Projections for overall volume vary between +/-20%
  - Inconclusive



Source: Dettinger, 2005

Different Approaches

Top Down

Emissions

Climate

Water Supply

GCM Data

Hydrologic Modeling

Decision Support Modeling

Assessment of impacts & adaptation options

Bottom Up

Water Supply

Available Resources

General Findings

Decision Support Modeling

Identify the likely cause-effect pathways

“Book-end” climate extremes

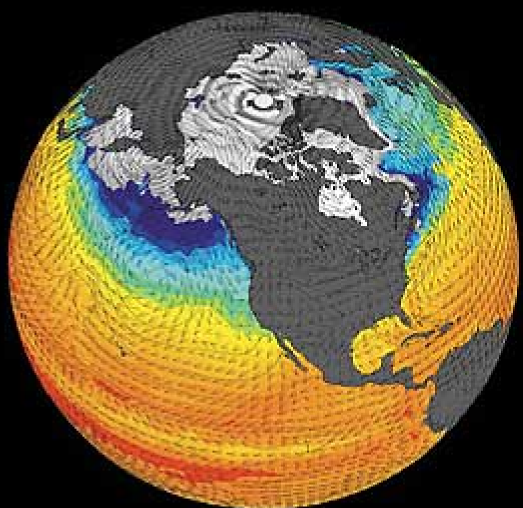
What tools are available?

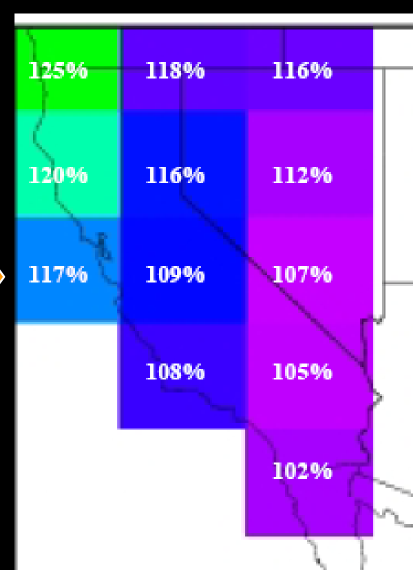
- General Circulation Models (GCMs)
- Hydrologic Models
- Operations Models
- Demand / Land Use Models
- Geographic Information Systems (GIS)

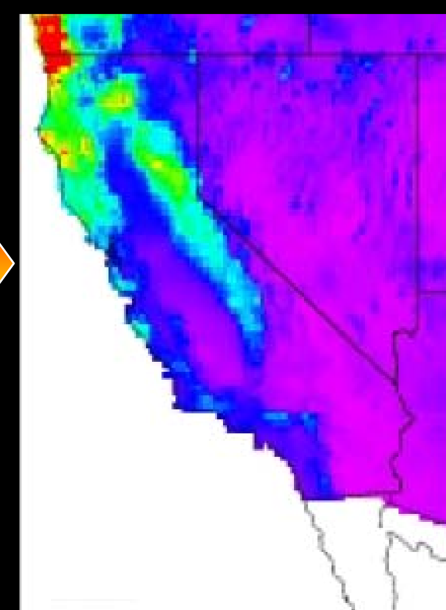
Typically, several of these models are needed for a robust climate change analysis

General Circulation Models (GCMs)

- Atmospheric response to greenhouse gas concentrations
- Inherent uncertainty in downscaling
- Reluctance by Water Managers
- Typically, several of these models are needed for a robust climate change analysis







Using GCM Information

Top – Down

- Develop synthetic hydrology from GCM (CCCC, 2006)
  - Stationarity **not** preserved
- Perturb historic hydrology based on GCM (DWR, 2006)
  - Stationarity preserved

Bottom – Up

- Hypothetical scenarios indirectly based on GCM
  - Manually modify input into local hydrologic models (Inland Empire, CA, 2007)

What tools are available?

- General Circulation Models (GCMs)
- Hydrologic Models
- Operations Models
- Demand / Land Use Models
- Geographic Information Systems (GIS)

Decision Support System

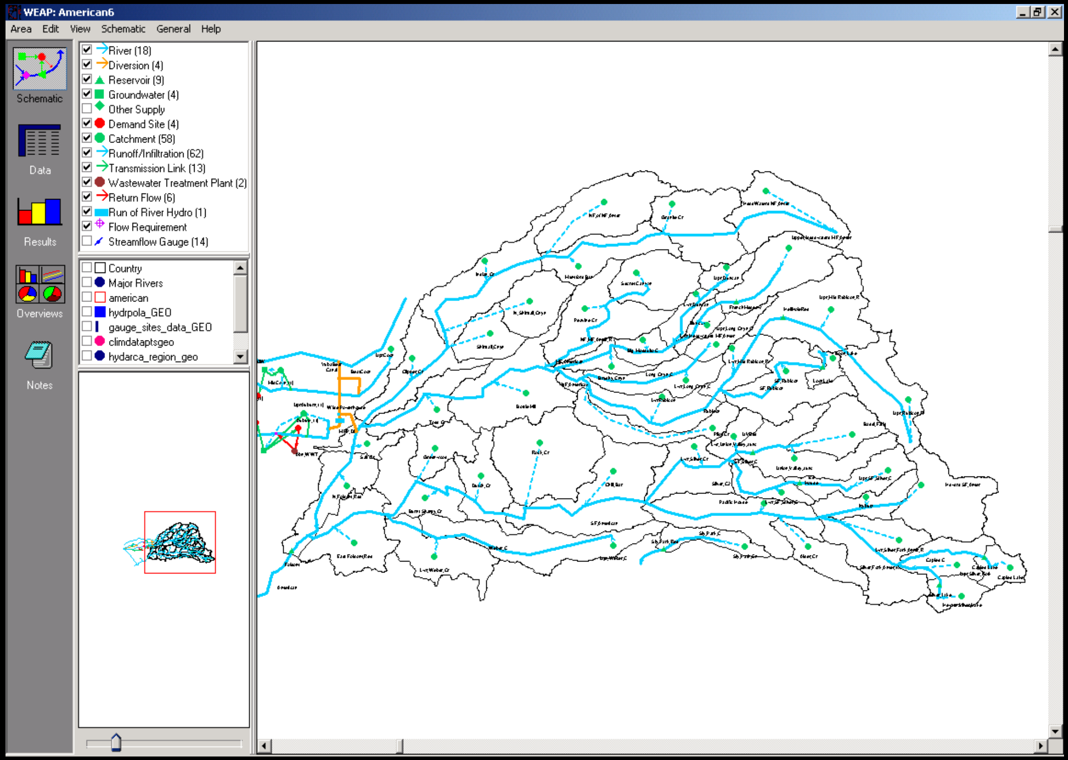
Decision Support System Models

- Supports business and organizational decision-making activities by developing Scenarios
- Balance Objectives
- Optimize objectives functions
- Uncertainty calculations (Monte Carlo Simulations)

Example: WEAP

Water Evaluation And Planning

- Specific to water resource planning
- Integrates with other models



Decision Support System Models

WEAP - Water Evaluation And Planning

- Specific to water resource planning
- Integrates with other models

California Climate Center

Case study for Sac Valley under Governor Schwarzenegger's Executive Order S-3-05

CA Department Water Resources

WEAP as platform for Update to the CA Water Plan

Placer County Water Agency, El Dorado Irrigation District

CC analysis of the American River Watershed, hydrologic impacts

Portland Water Bureau

Integrated water planning & CC analysis

Inland Empire Utility Agency

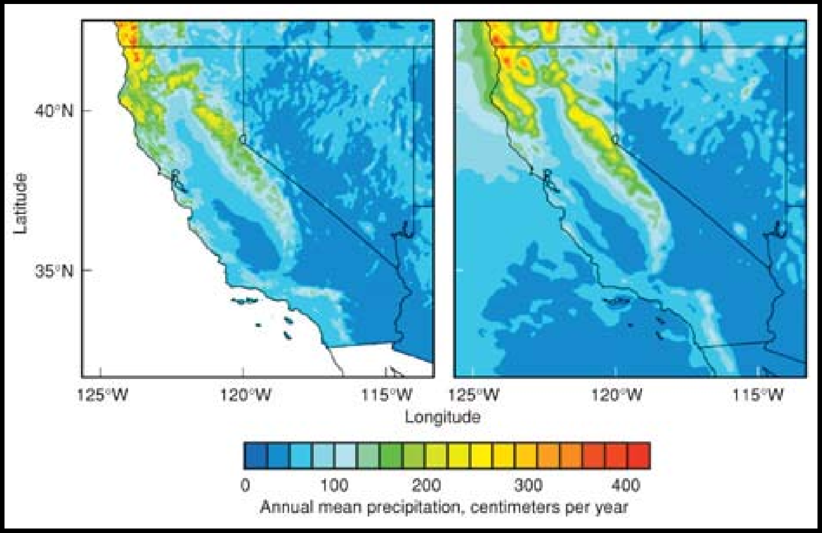
UWMP update and CC analysis

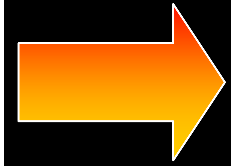
EBMUD

WEAP as a water supply portfolio screening tool

Which approach is appropriate?

Link future climate and water supply reliability

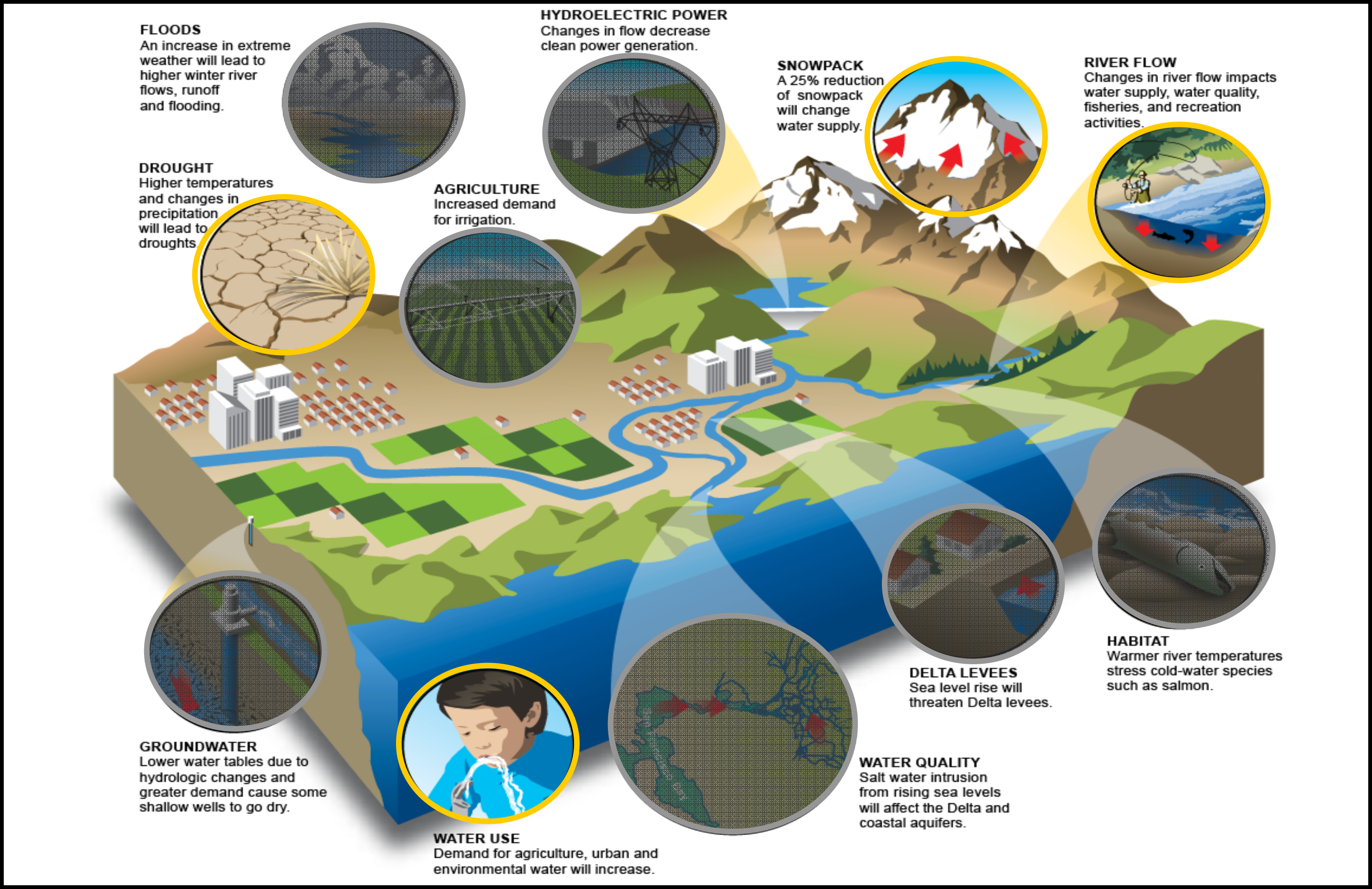




Bottom-Up Approach for EBMUD

- IPCC 2007, NRDC 2007, AWWA 2007
- No GCM derived Hydrology
  - Not readily available for the Mokelumne
  - Uncertainty in climate derived hydrology
- Time and budget
- Uses available tools

What parameters do we need to analyze?



Source: California DWR, 2008

Cause – Effect pathways

- Temperature increase
  (between 1980-2040)
  - 2º C
  - 3º C
  - 4º C

→

- Spring snowpack reduction
- Demand increase
  - For every 1º increase in average temp, 1% increase in annual demand

- Decrease in precipitation
  - 10%
  - 20%

→

- Annual runoff reduction
  - 10%
  - 20%

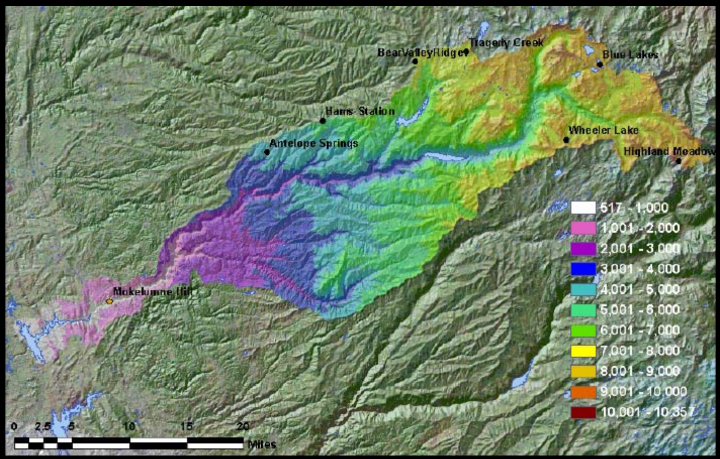
System Response to each variable was tested independently

Reduction in Spring Snowmelt

How do we determine earlier spring-runoff?

- EBMUD has critical watershed data
- Weather Station data since 1950
- Digital Elevation Model
- Snow course data statistically linked to Mokelumne Basin runoff.

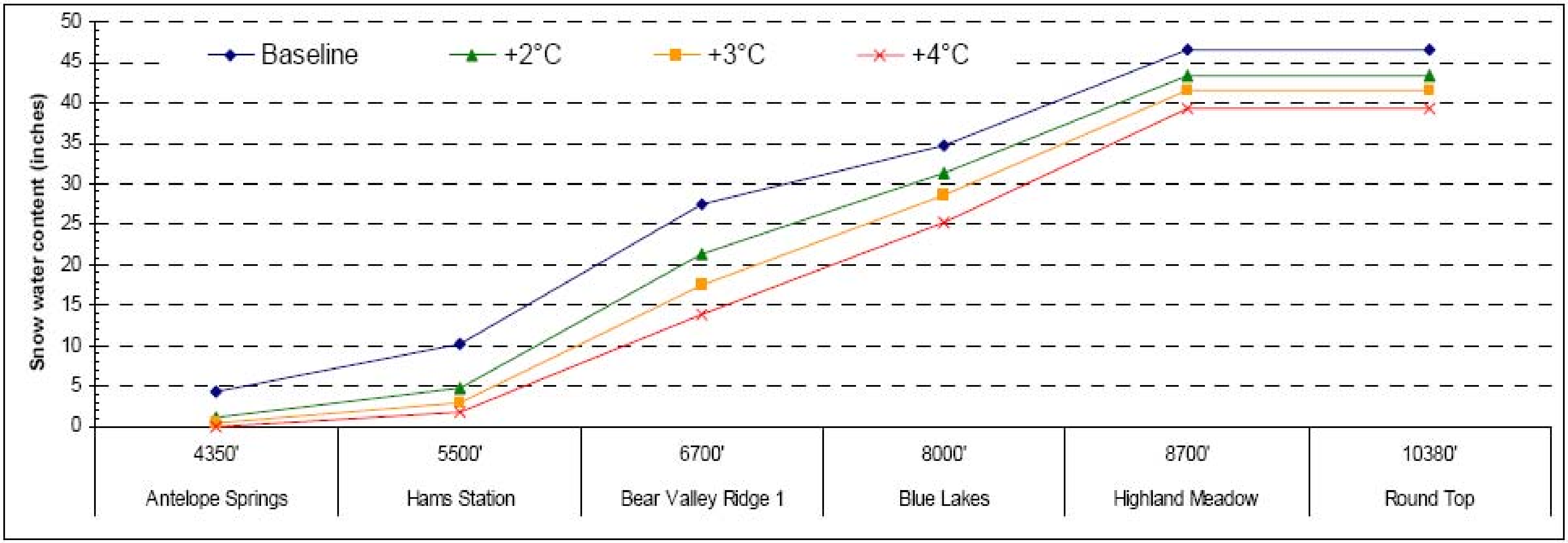
A GIS Question…



Source: EBMUD

Reduction in Spring Snowmelt

April 1st Snow Water Content at Various Temperature Increases



Source: EBMUD

IF April 1st snowpack is less AND

No decrease in annual precipitation THEN

Runoff volume shifted from April to July period to November to March period

Reduction in Spring Snowmelt

- 2^{o}C increase in temperature resulted in ~19% shift
- 3^{o}C increase in temperature resulted in ~28% shift
- 4^{o}C increase in temperature resulted in ~38% shift

These values are consistent with DWR's research (20 to 40%)
Findings consistent with local climate research (Roos)

Note: Temperature increases anticipated between 1980 and 2040

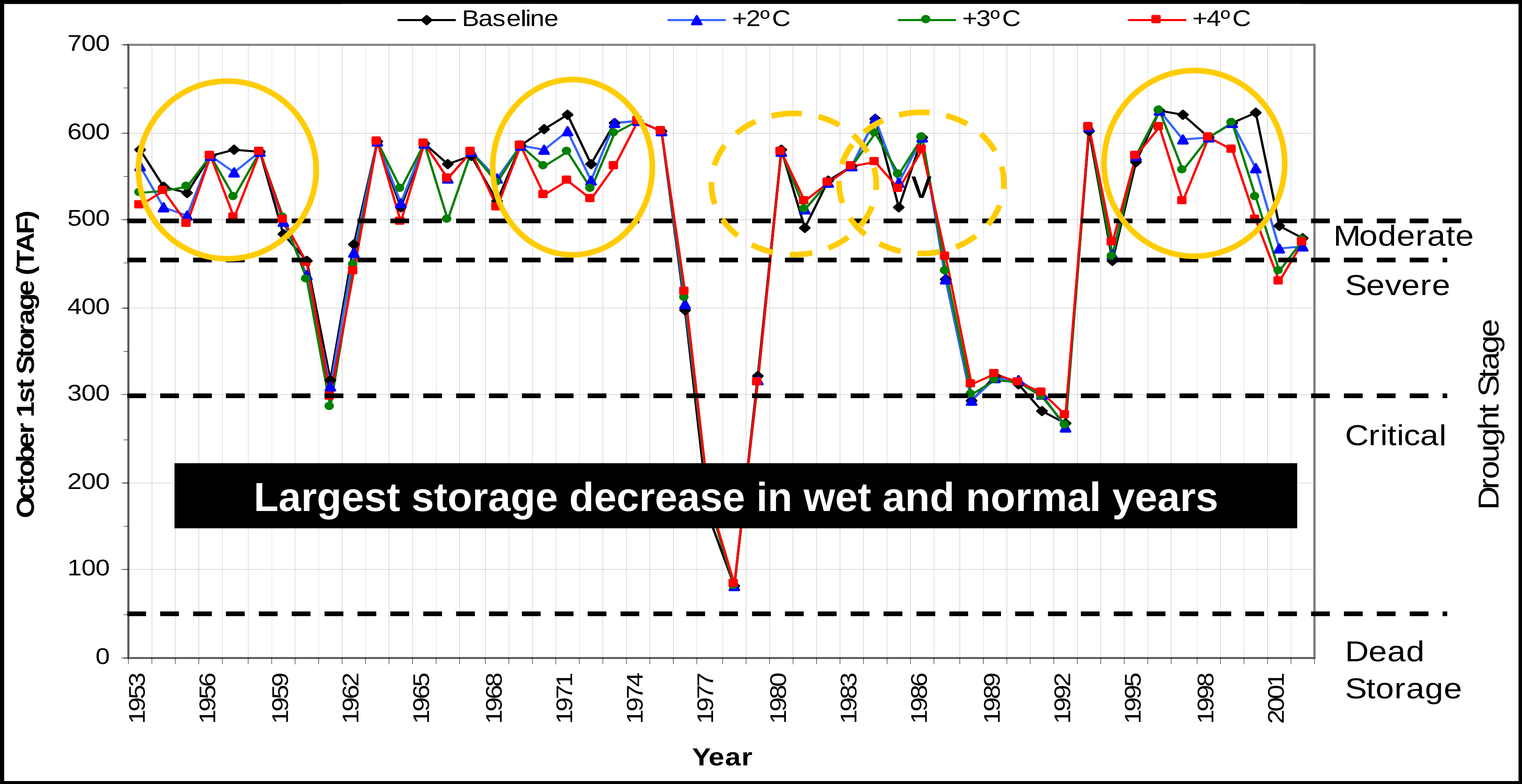
Results - Shift in spring runoff

Shift in spring runoff

- Carryover Storage decreased in half of years simulated
  - Average decrease 3% to 6%
  - Maximum decrease 8% to 16%
- Carryover Storage increased in one-third of years simulated
  - Average increase 3% to 4%
  - Maximum increase 10% to 12%
- Reasons?
  - Large amount of reservoirs storage
  - Operations

Results - Shift in spring runoff

Effect of shift in spring runoff on total system carryover storage



Results – Demand Increase

Temperature-induced demand increase

- Impacts were minimal at lowest temperature increase
- Carryover Storage decreased in half of years simulated
  - Average decrease 3%
  - Maximum decrease 8%
- 17% increase in customer shortages during the worst drought on record

Results – Precipitation Reduction

Decrease in annual Mokelumne runoff

- Carryover Storage 60 to 70% of years simulated
  - Average decrease 12 to 24%
  - Maximum decrease 47 to 76%
- Increase in customer shortages during worst drought on record
  - Shortage also appears (1987 to 1992)
- Highlights vulnerability to longer or more intense droughts

Limitations and Benefits

- This approach does not incorporate synergistic affects
- Trade-off between model sophistication and uncertainty
- Benefit in simplifying approach
  - Water Managers
  - Stakeholders

Conclusions

- Diversify water supply portfolios
  - Groundwater Banking, increased reservoir storage, desalination
- Implement “no regret” actions
  - Conservation
  - Recycled Water
- Adaptive Management
  - Decrease time between WSMP updates (10 years to 5 years)
  - Continue monitoring changes in the Mokelumne Watershed (SWE, temps, etc.)
  - The tools developed can be used in the future

Thank You

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