

“Early Look” at Climate Change for BDCP

BDCP Conveyance Working
Group/HOTT

June 4, 2009

PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Study Objectives

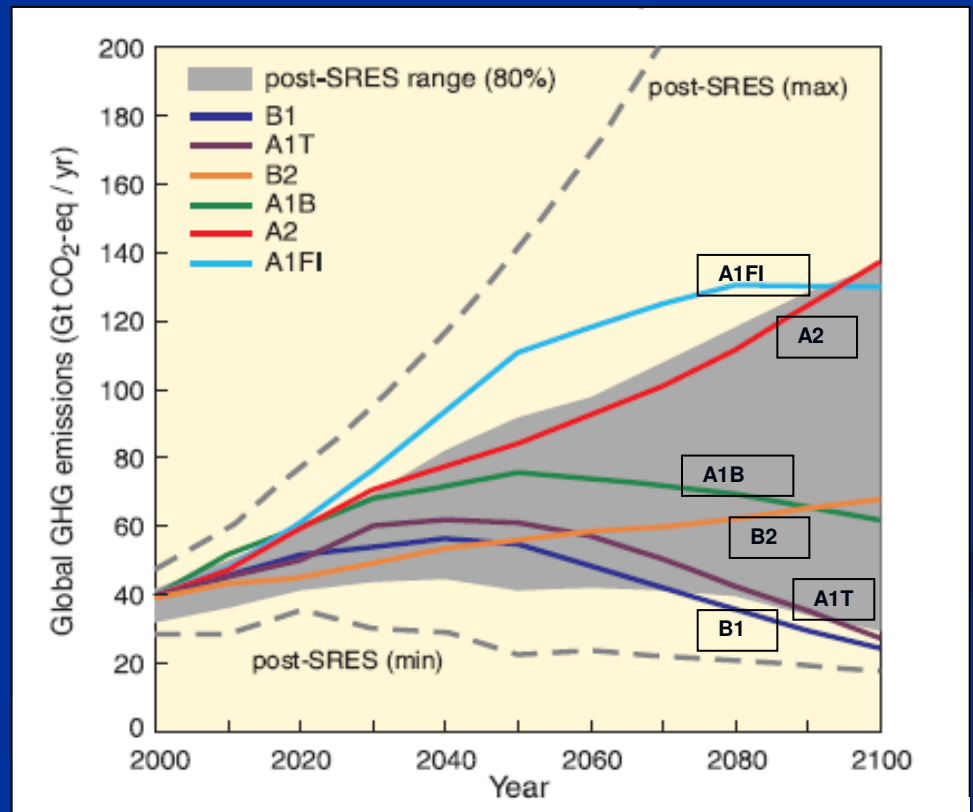
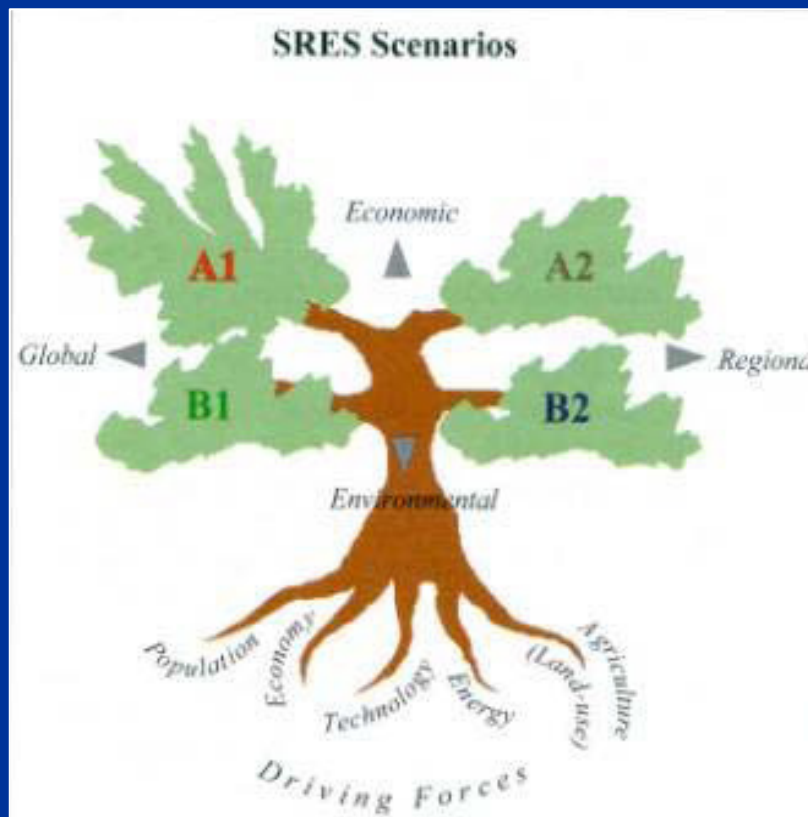
- Provide an preliminary (“early”) look at climate change with focus on BDCP
- Assist in development of BDCP strategies
- Not an impact assessment
- Test methods, assumptions, and tools

Climate Change, Scenarios, and Methodology

PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Emission Scenarios used for Modeling

The IPCC's Special Report on Emissions Scenarios (SRES) detailed future emission scenarios to be used for driving global circulation models to develop climate change scenarios (IPCC 2000)

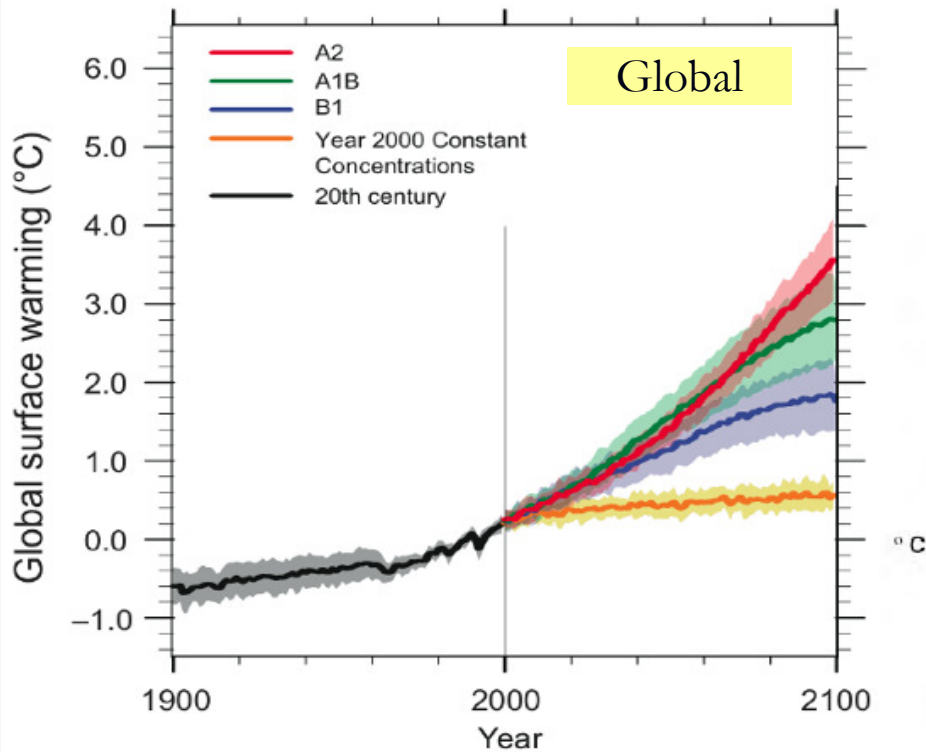


Source: IPCC 2007

PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

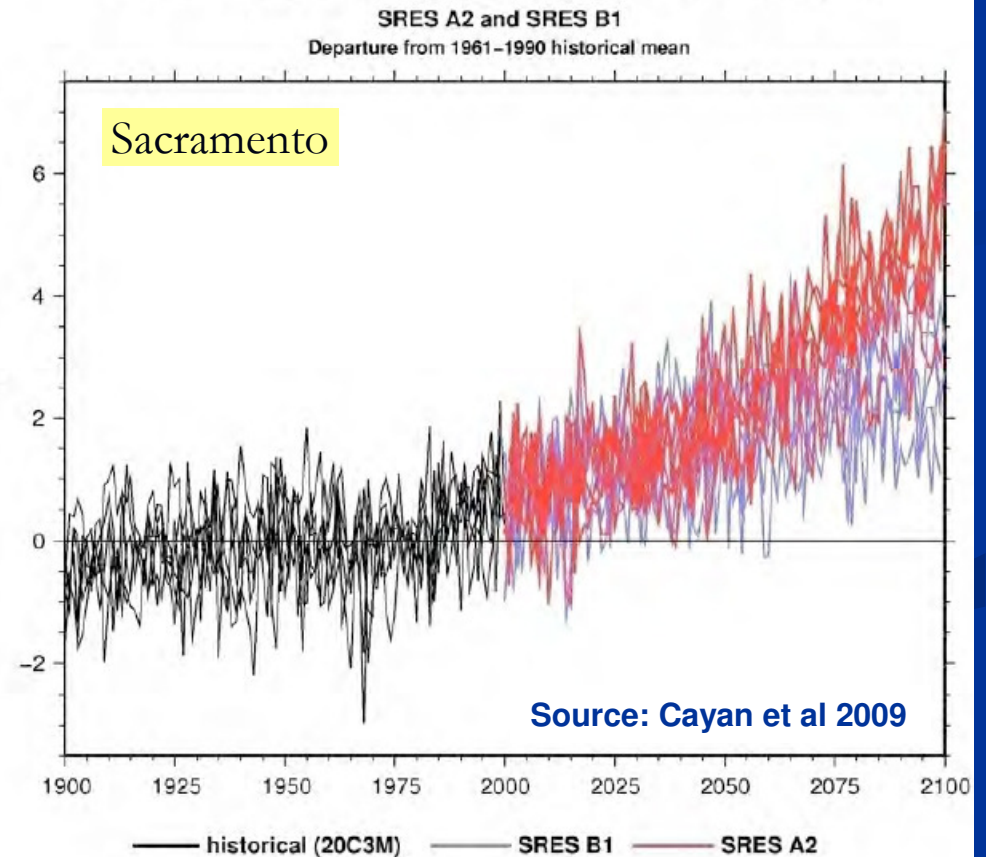
Projected Temperature Changes

Multi-model Averages and Assessed Ranges for Surface Warming



Source: IPCC 2007

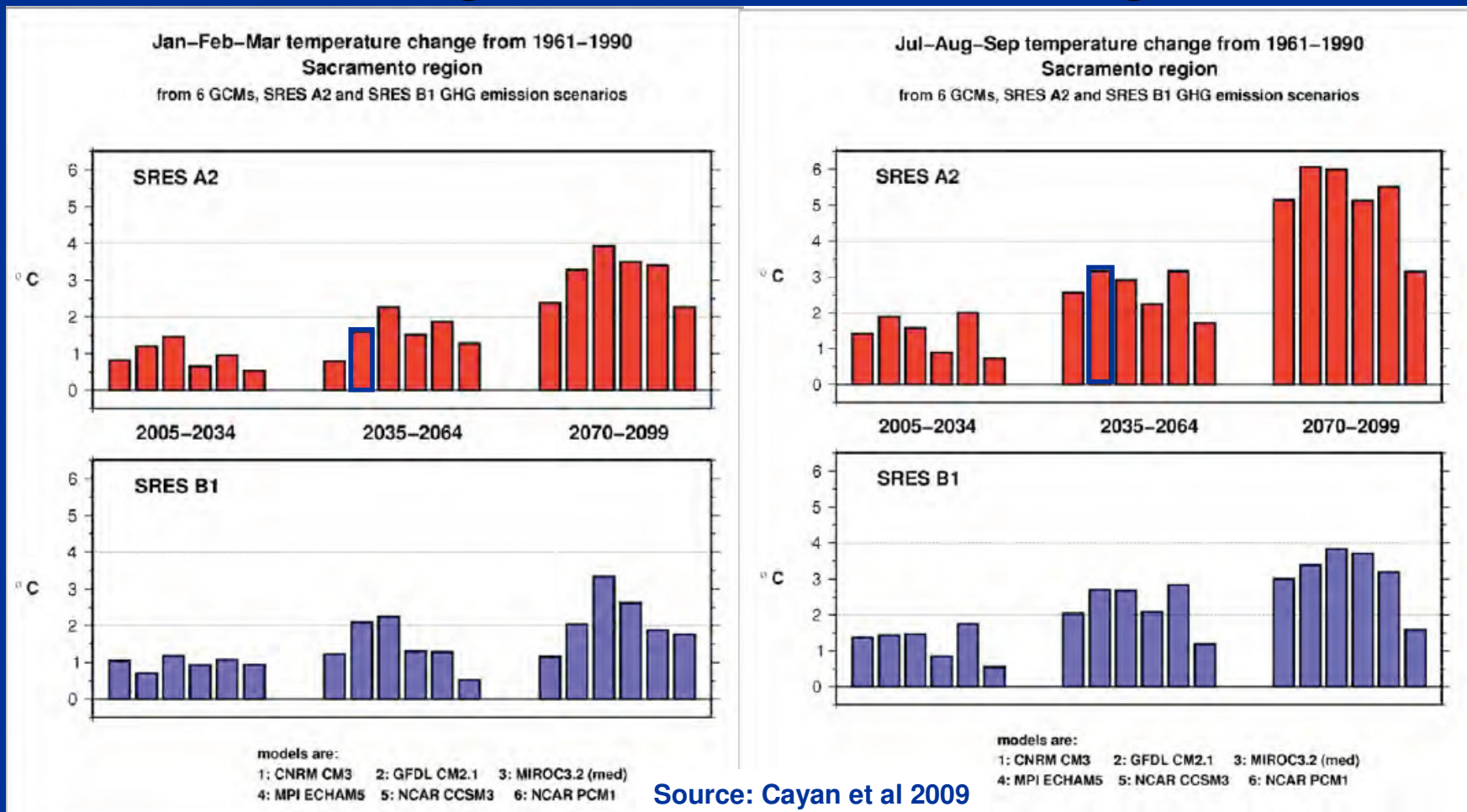
Annual Temperature Projections, Sacramento region



Source: Cayan et al 2009

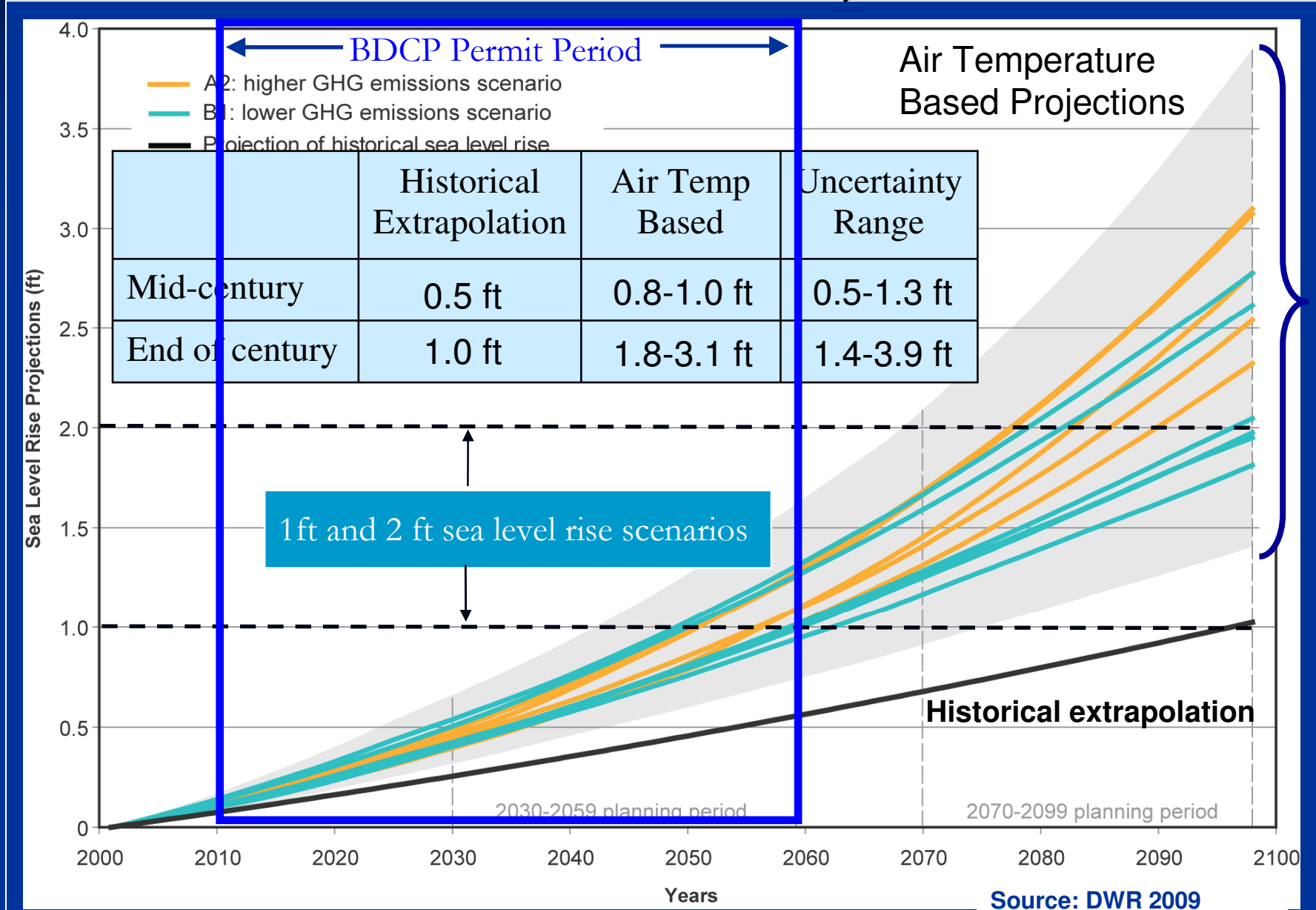
Projected Seasonal Temperature Changes

- Consistent warming trend in all GCM simulations
- Greater warming in summer and interior regions



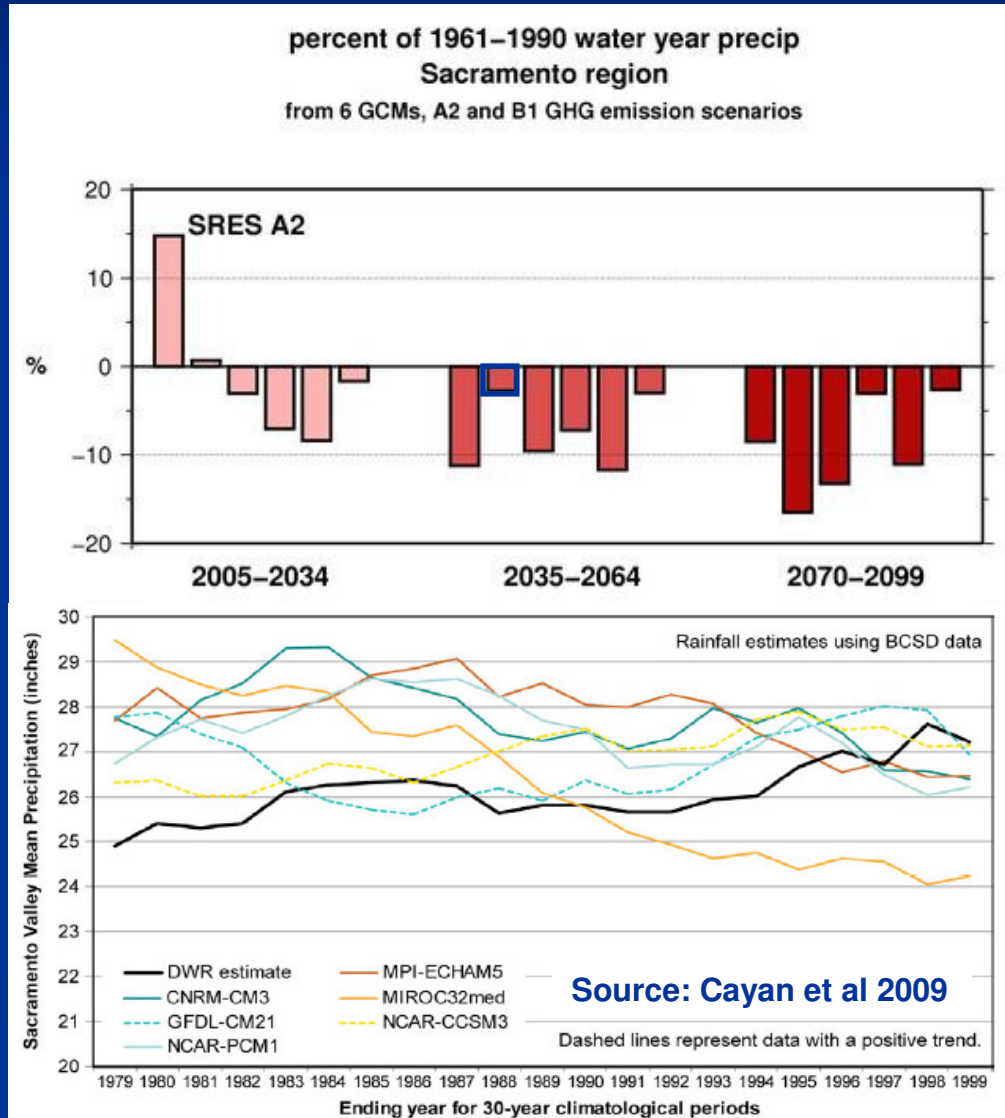
Source: Cayan et al 2009

Sea Level Rise Projections



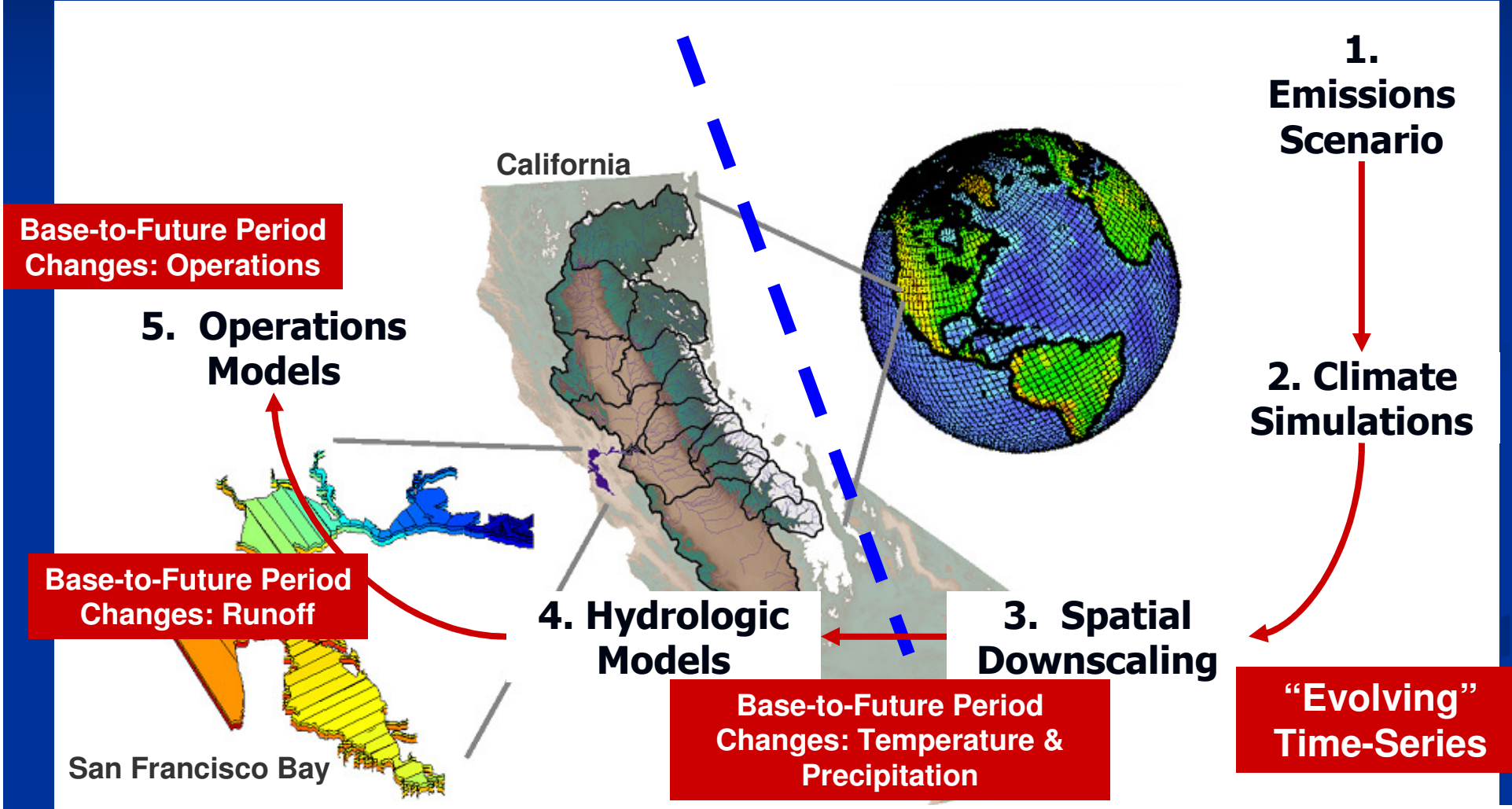
Projected Precipitation Changes

- Historical precipitation trends not well captured by current GCMs
- Precipitation trend projections have larger uncertainty than temperature
- CAT scenarios show drying trend in most models
- Drying trend, however, is not exhibited in all GCMs
- Increasing sea level pressure may be cause of northerly push in storm tracks



PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Scenario Approach to Climate Change Assessments



Adapted from Cayan and Knowles, SCRIPPS/USGS, 2003

Climate Change Methodology and Assumptions

- Climate Action Team selected scenarios (6 GCMs x 2 emission scenarios)
- Downscaling and hydrologic analysis performed for all major watersheds
- Historic inflows are “perturbed” to reflect climate change future (CALSIM II)
- Hydrologic indices and Sac Valley consumptive use updated
- Selected one scenario for this analysis:
 - SRES A2 (higher emission scenario)
 - GFDL CM2.1 general circulation model
 - Mid-century (2035-64)
 - Higher warming, but relatively modest changes to precipitation
- Sea level rise (1-2 ft) incorporated through new ANNs
 - DWR methodologies applied
 - DSM2 boundary conditions adjusted for SLR and increased salt transport

Projected Effects on Rim Station Hydrology

PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

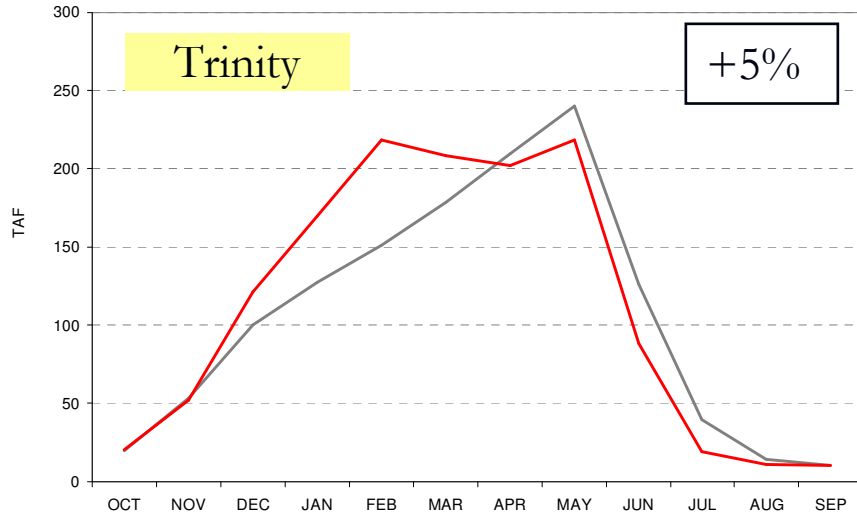
PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Projected Sacramento Valley Inflow Hydrograph Changes

Multi Study Comparison - Long Term Monthly Average Results (1922-2003)

Trinity R Inflow to Trinity Lake

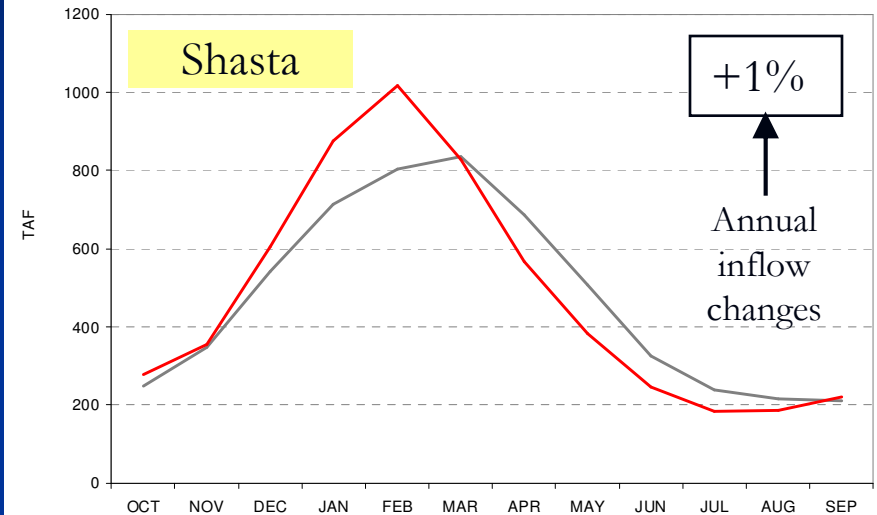
— Historic — GFDL_CM2.1 A2 2035-64



Multi Study Comparison - Long Term Monthly Average Results (1922-2003)

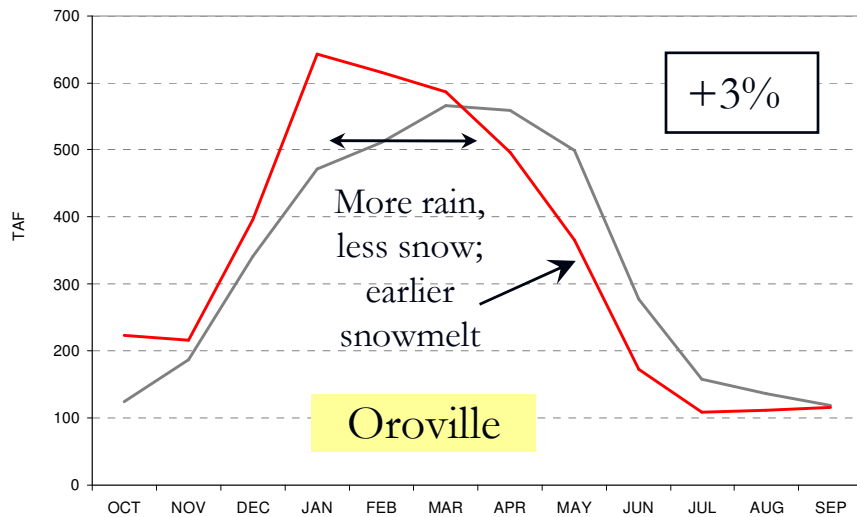
Shasta Inflow

— Historic — GFDL_CM2.1 A2 2035-64



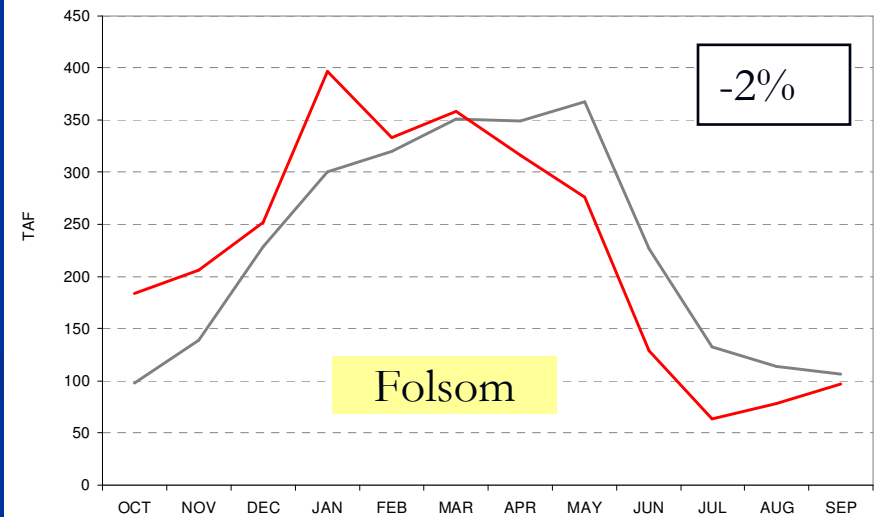
Feather R Inflow to Oroville

— Historic — GFDL_CM2.1 A2 2035-64



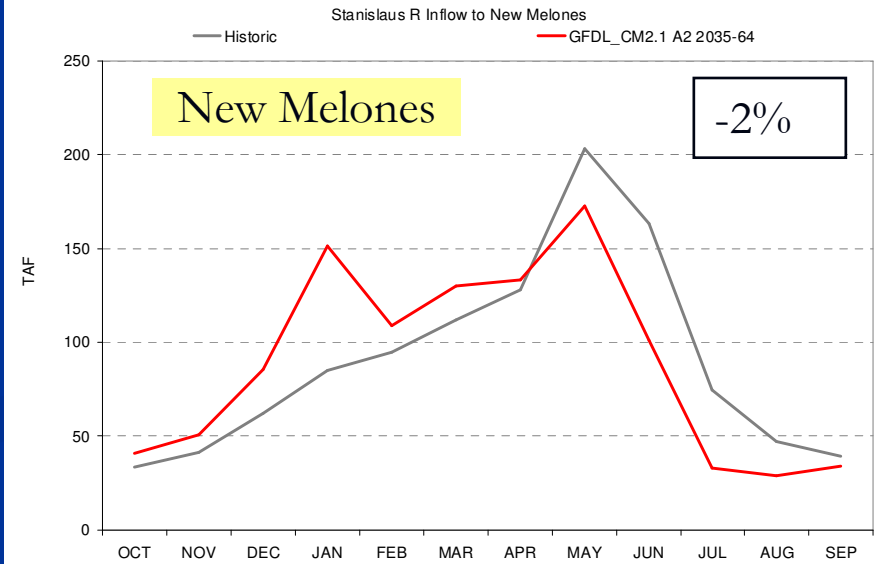
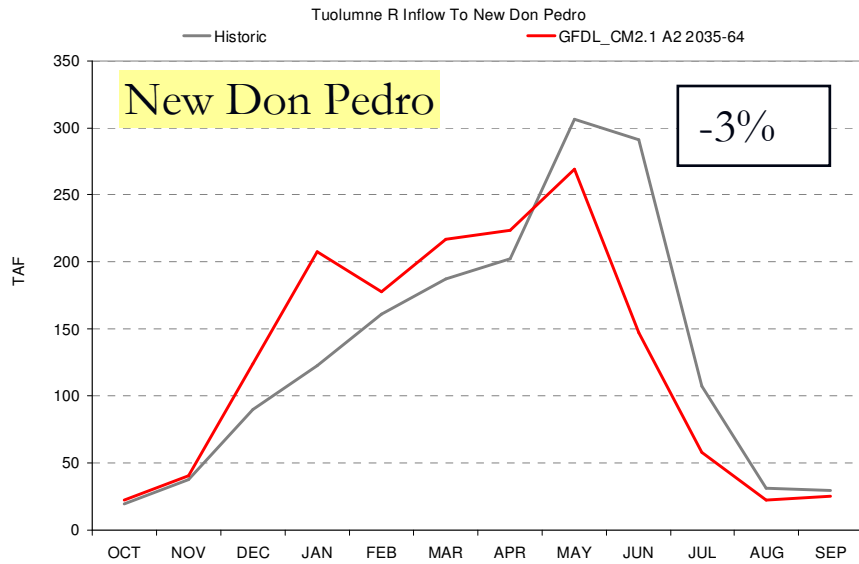
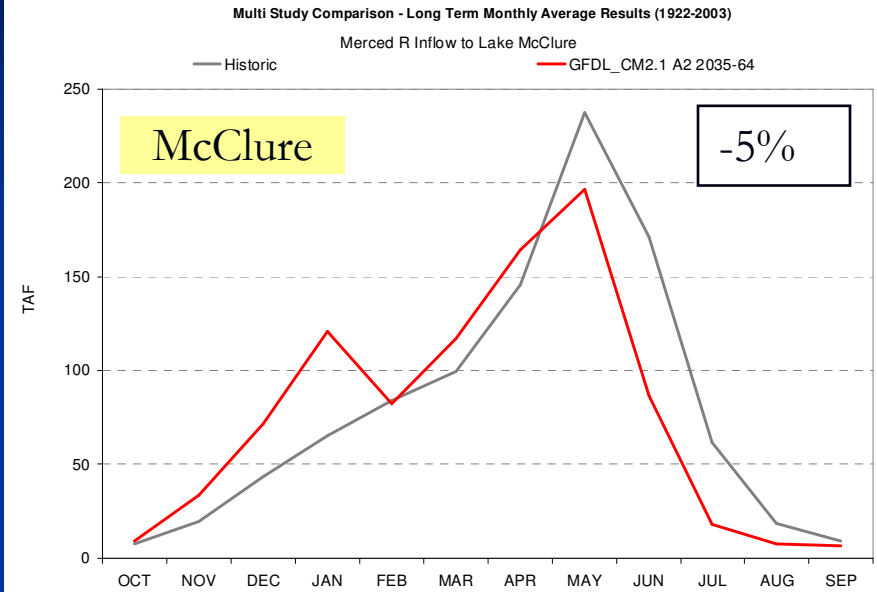
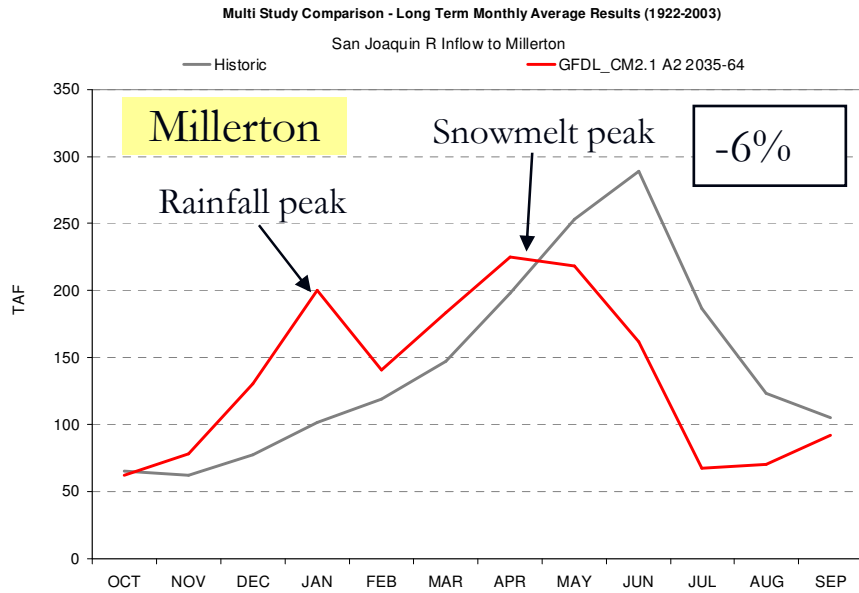
American R Inflow to Folsom

— Historic — GFDL_CM2.1 A2 2035-64



PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

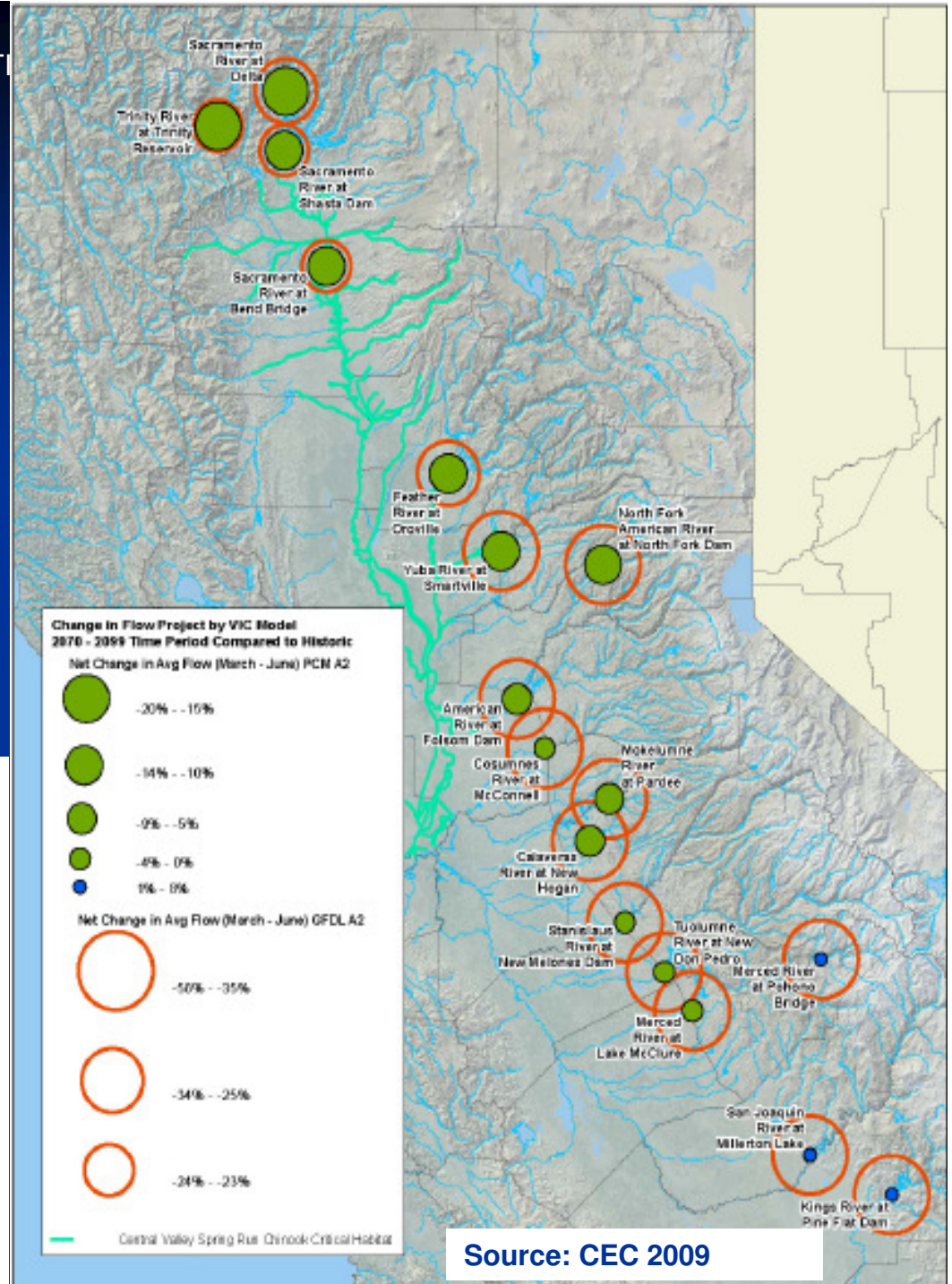
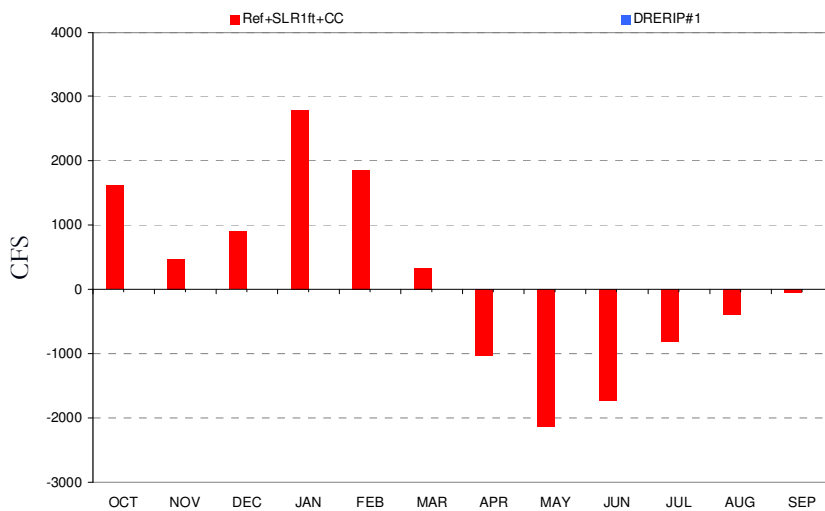
Projected San Joaquin Valley Inflow Hydrograph Changes



PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Hydrology Changes during March - June

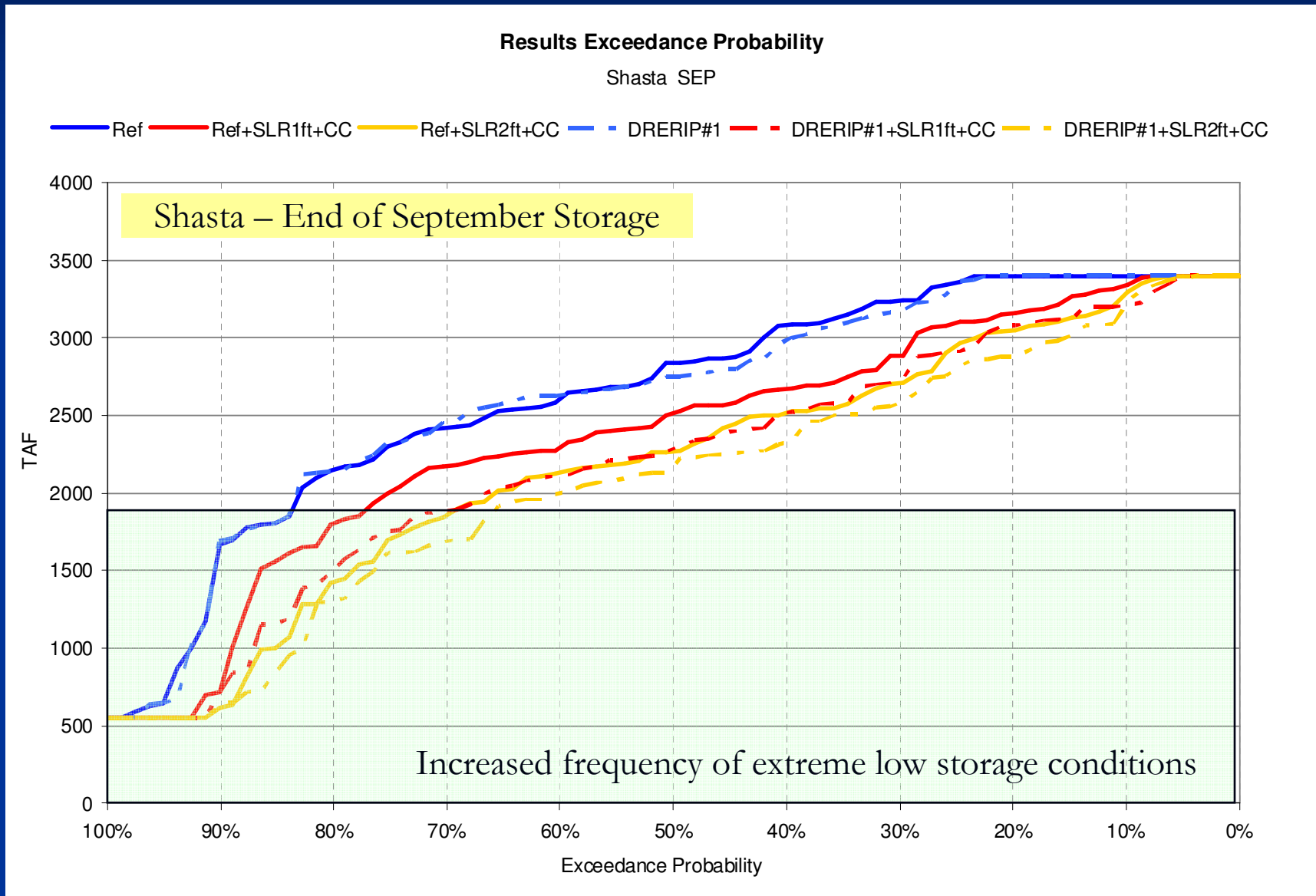
Change in Inflows to Oroville



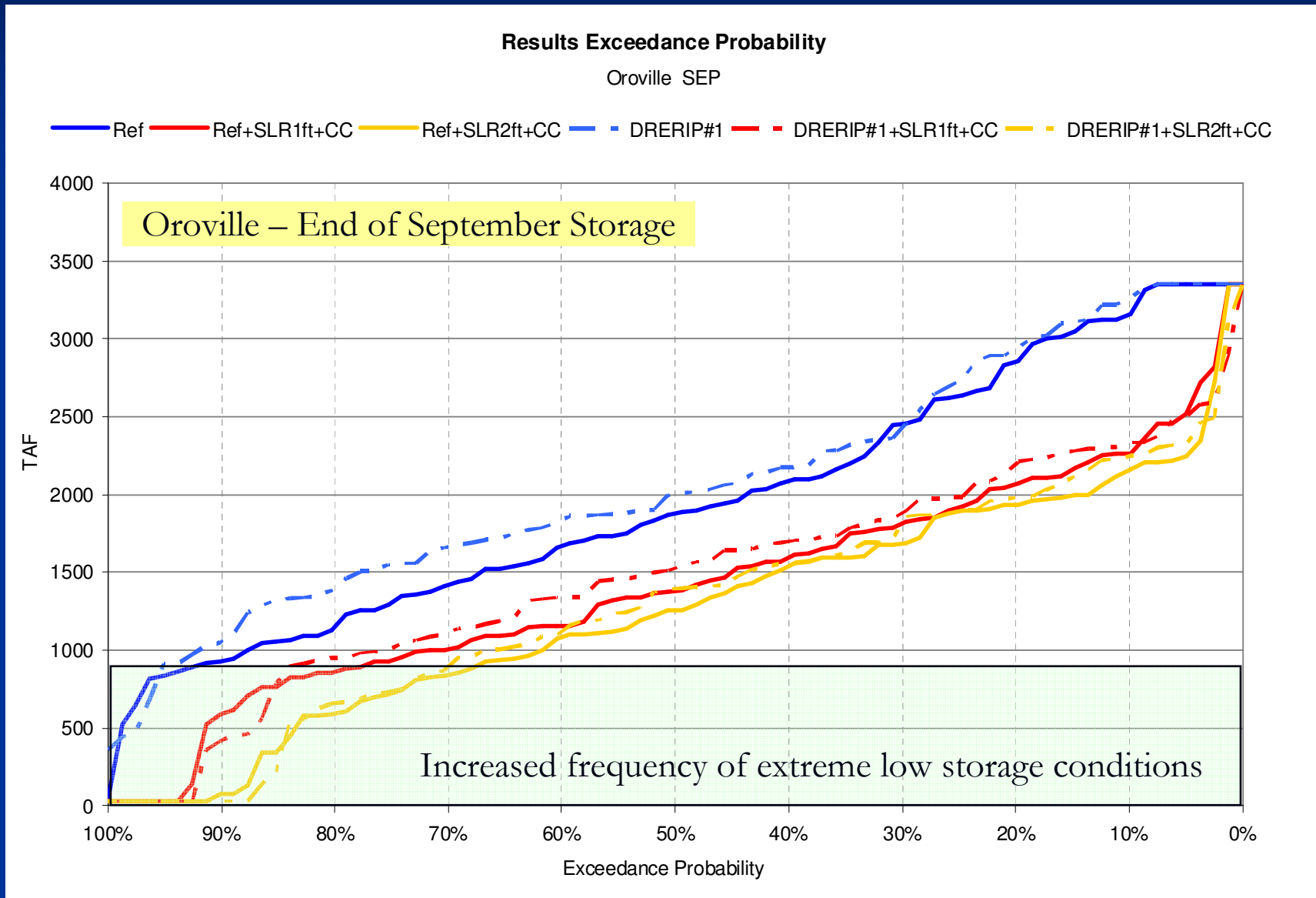
Potential Impacts on SWP and CVP Operations

- Preliminary studies with one climate change scenario
- Studies were not optimized wrt delivery allocations and San Luis storage operations
- Studies should be considered as “Without Adaptation”
 - No changes in flood control rules
 - No changes in Delta standards
 - No changes in policy rules
 - No changes in export demand
 - No changes in facilities
 - Only limited changes to SWP-CVP operational rules

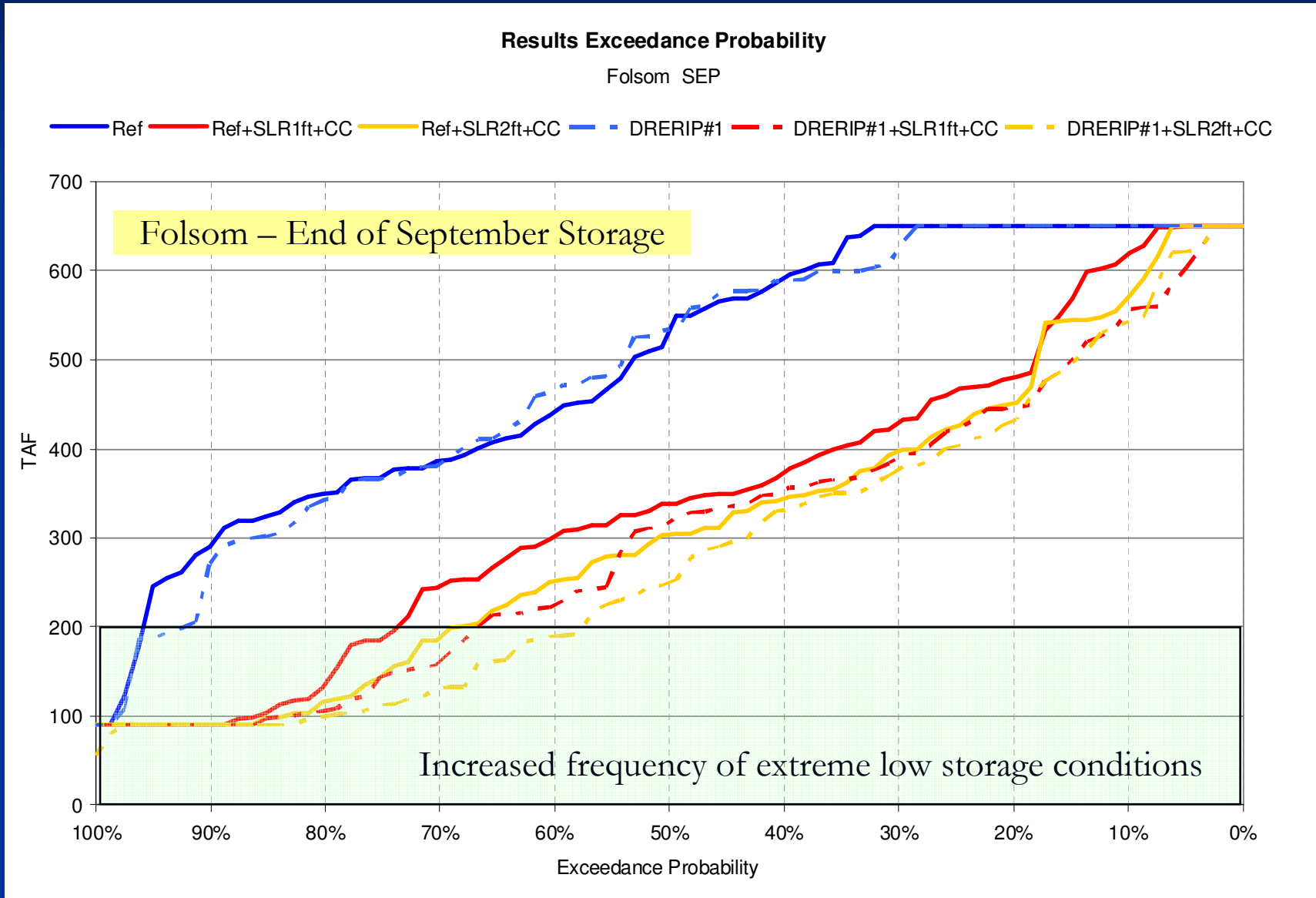
Potential Impacts on SWP and CVP Operations



Potential Impacts on SWP and CVP Operations

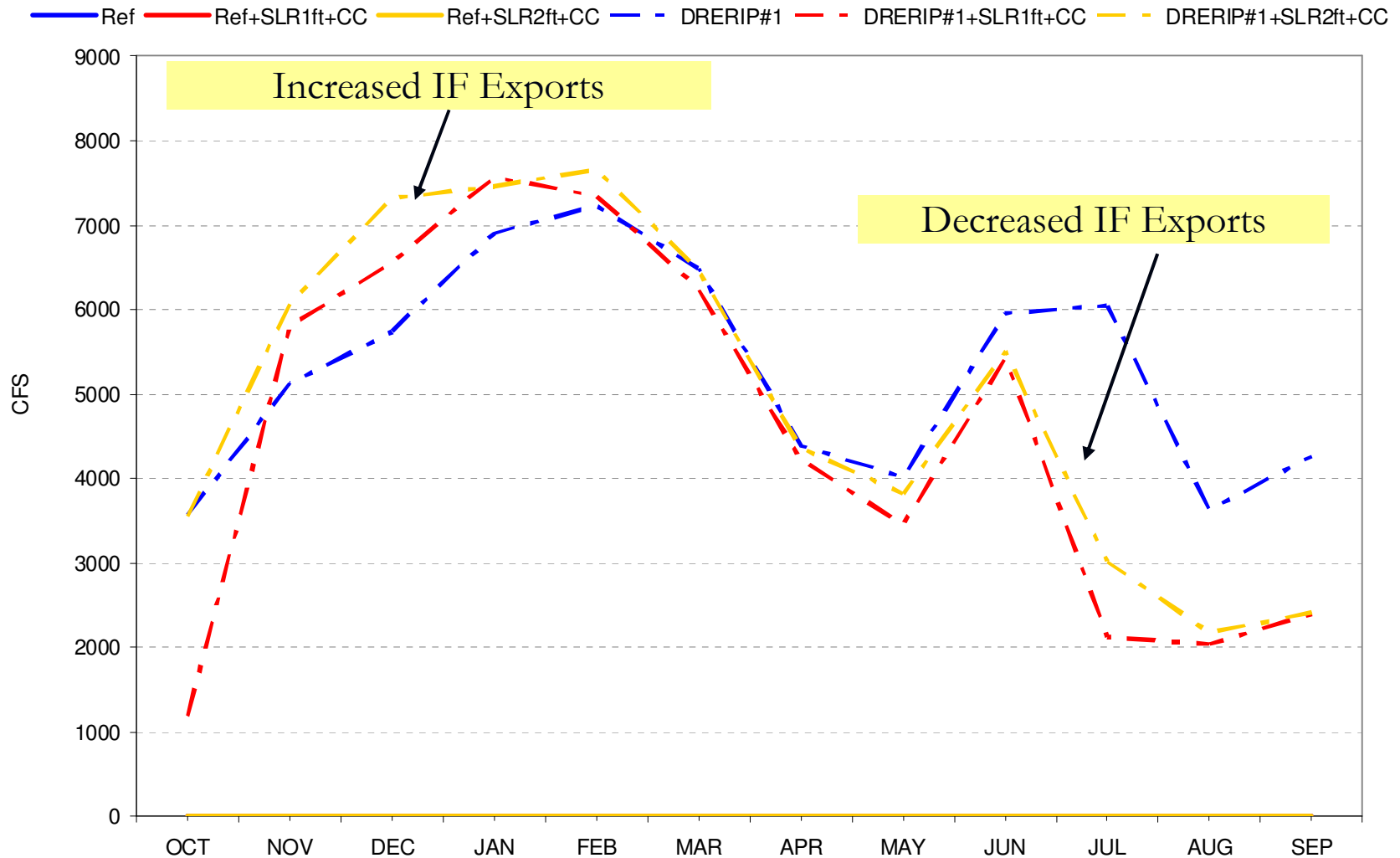


Potential Impacts on SWP and CVP Operations



Timing of Exports

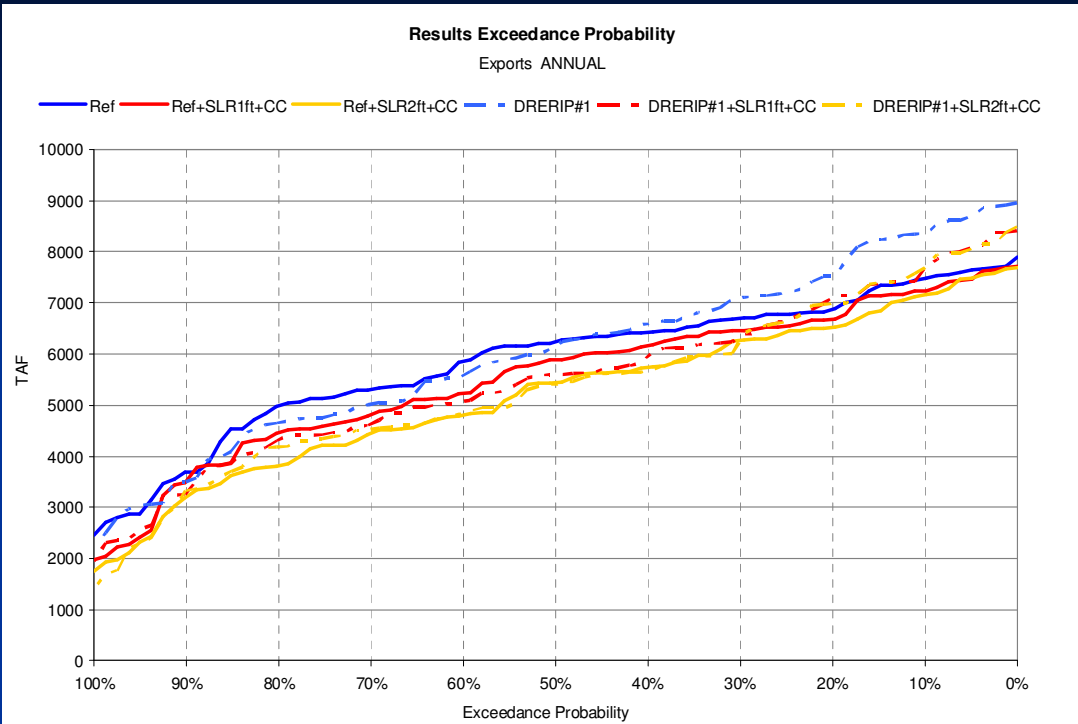
Multi Study Comparison - Long Term Monthly Average Results
Total IF



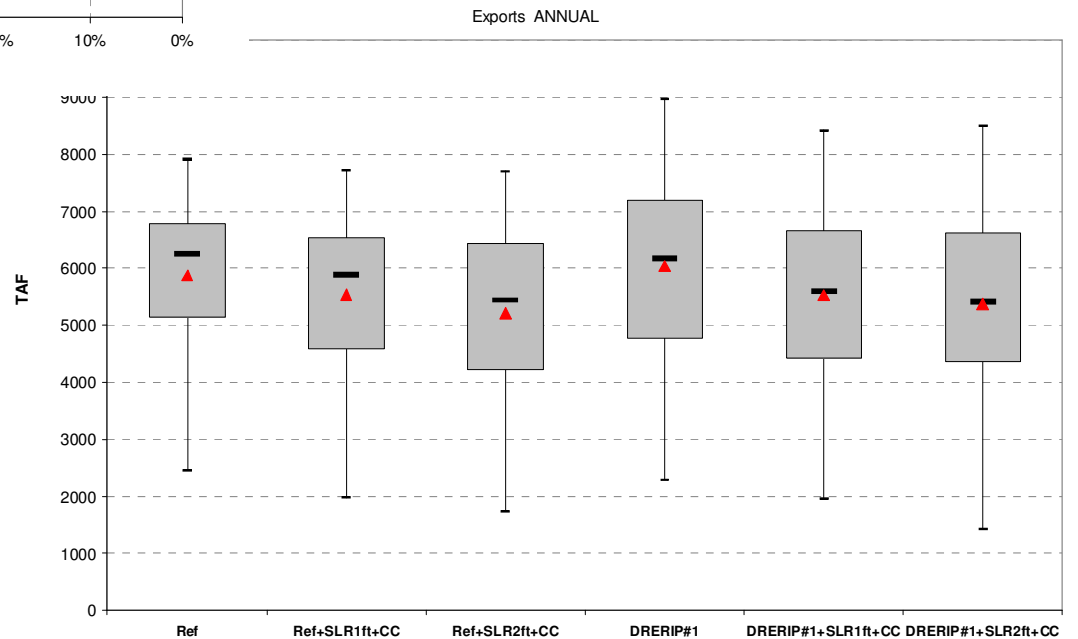
PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Annual Export Reliability Results

DRERIP#1 Assumptions



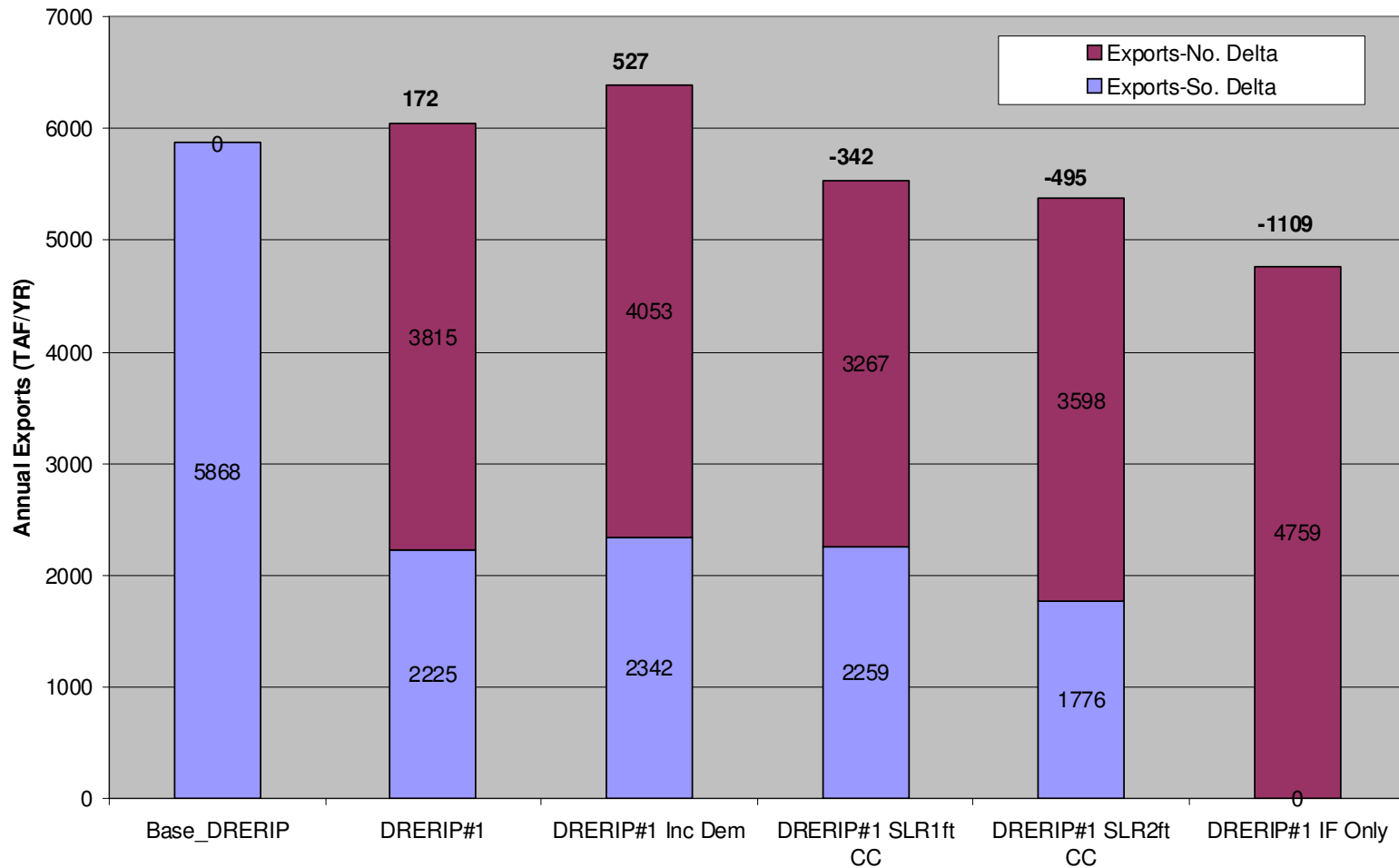
Single Month Box Plot Study Comparison
th to 75th percentile range, whiskers=min and max, dash=median, triangle=mean)



South vs North Delta Exports

DRERIP#1 Assumptions

Long-Term Annual Distribution of SWP and CVP Delta Exports



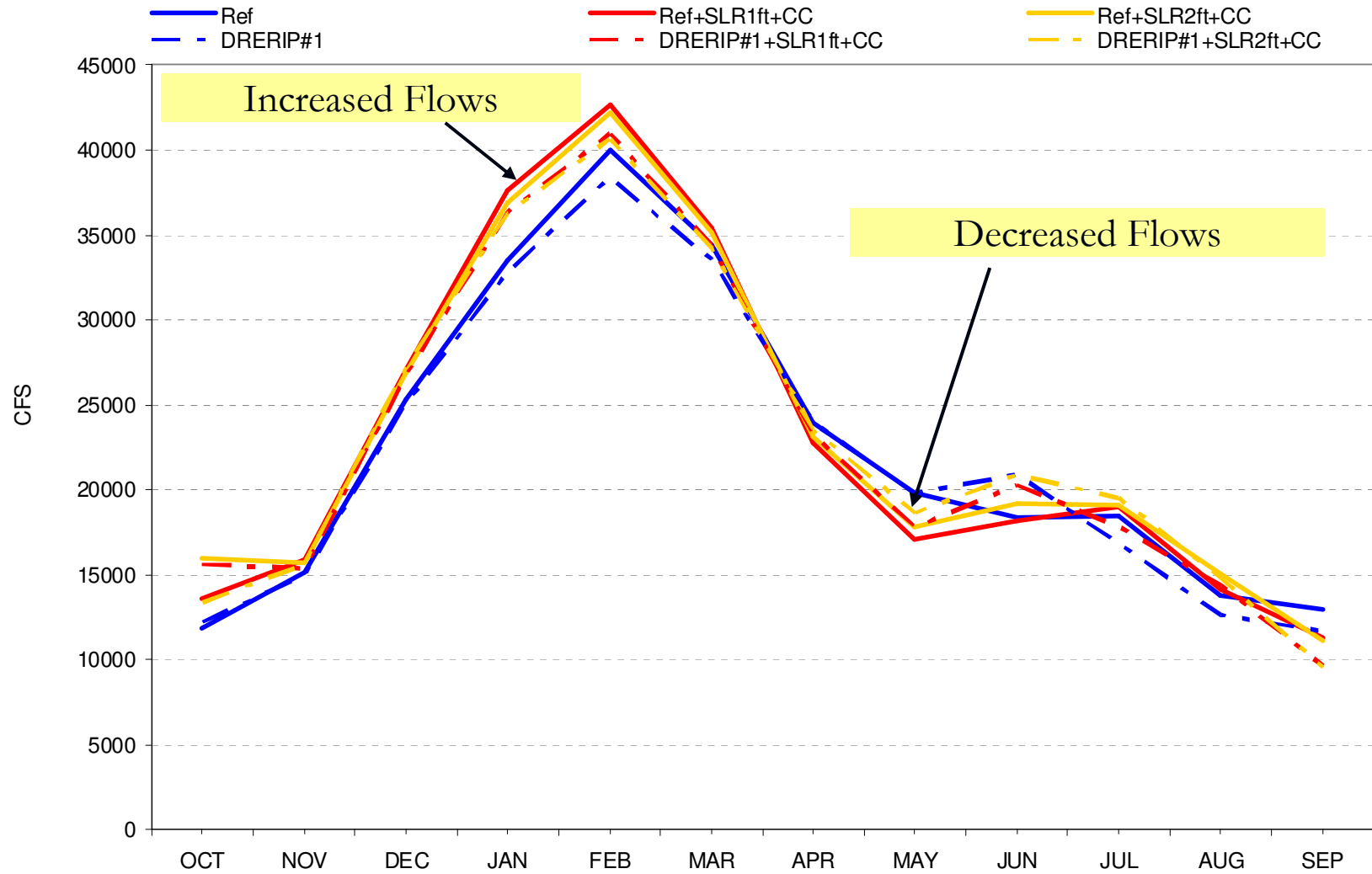
Potential Impacts to Delta Flows and Water Quality

PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Sacramento River Flows

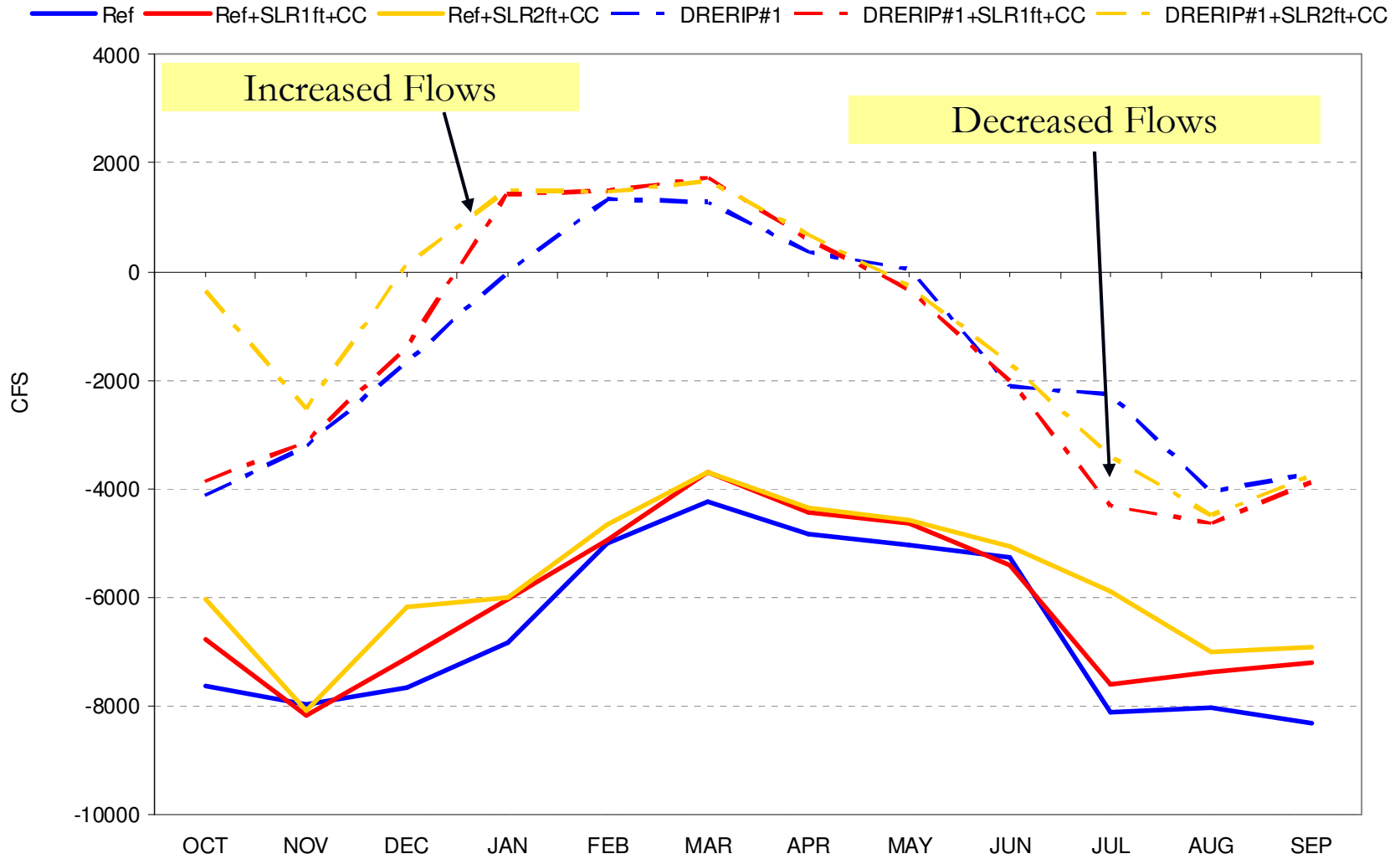
Multi Study Comparison - Long Term Monthly Average Results

Sac R @ Hood



OMR Flows

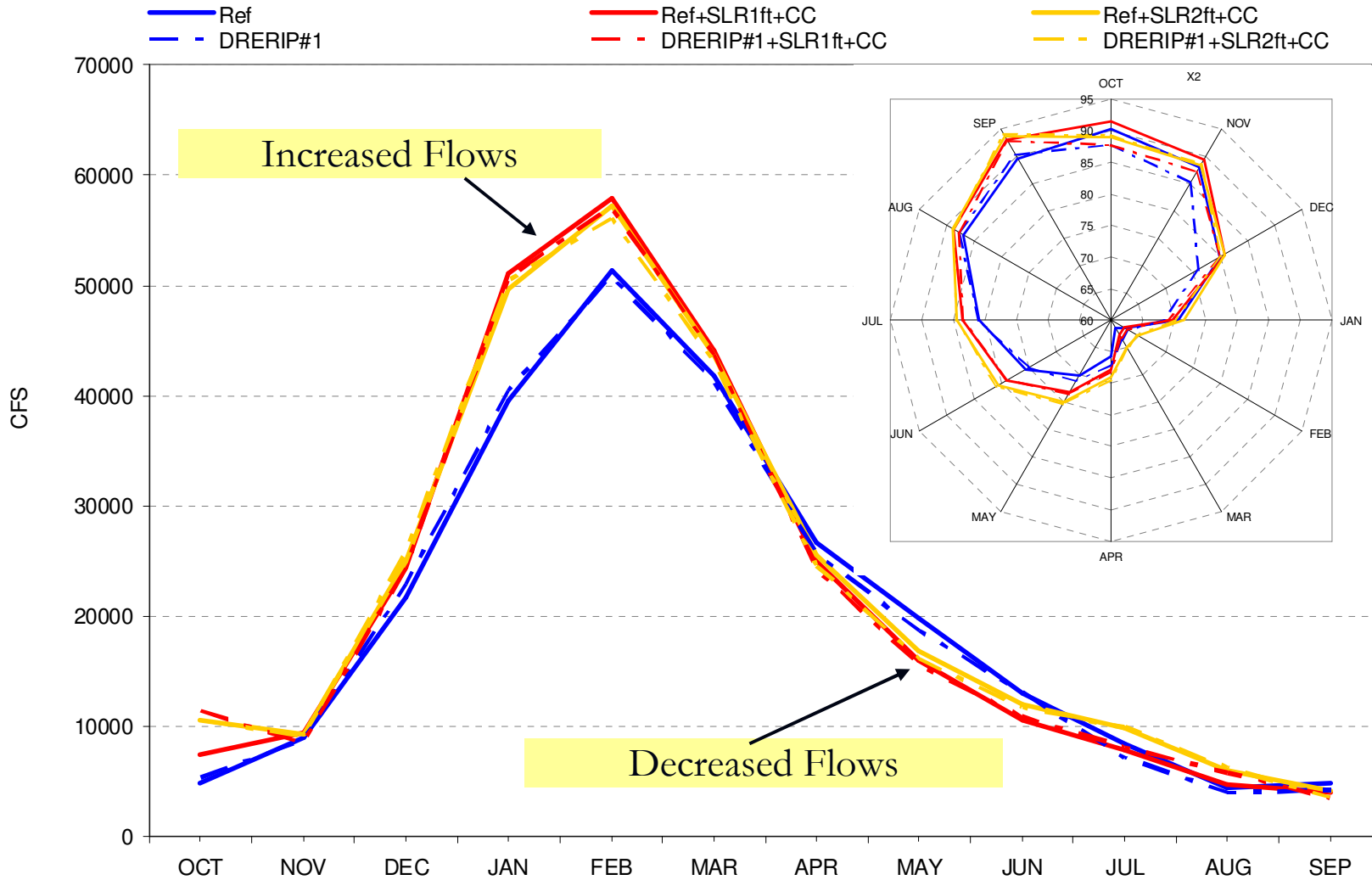
Multi Study Comparison - Long Term Monthly Average Results
OMR



Delta Outflow

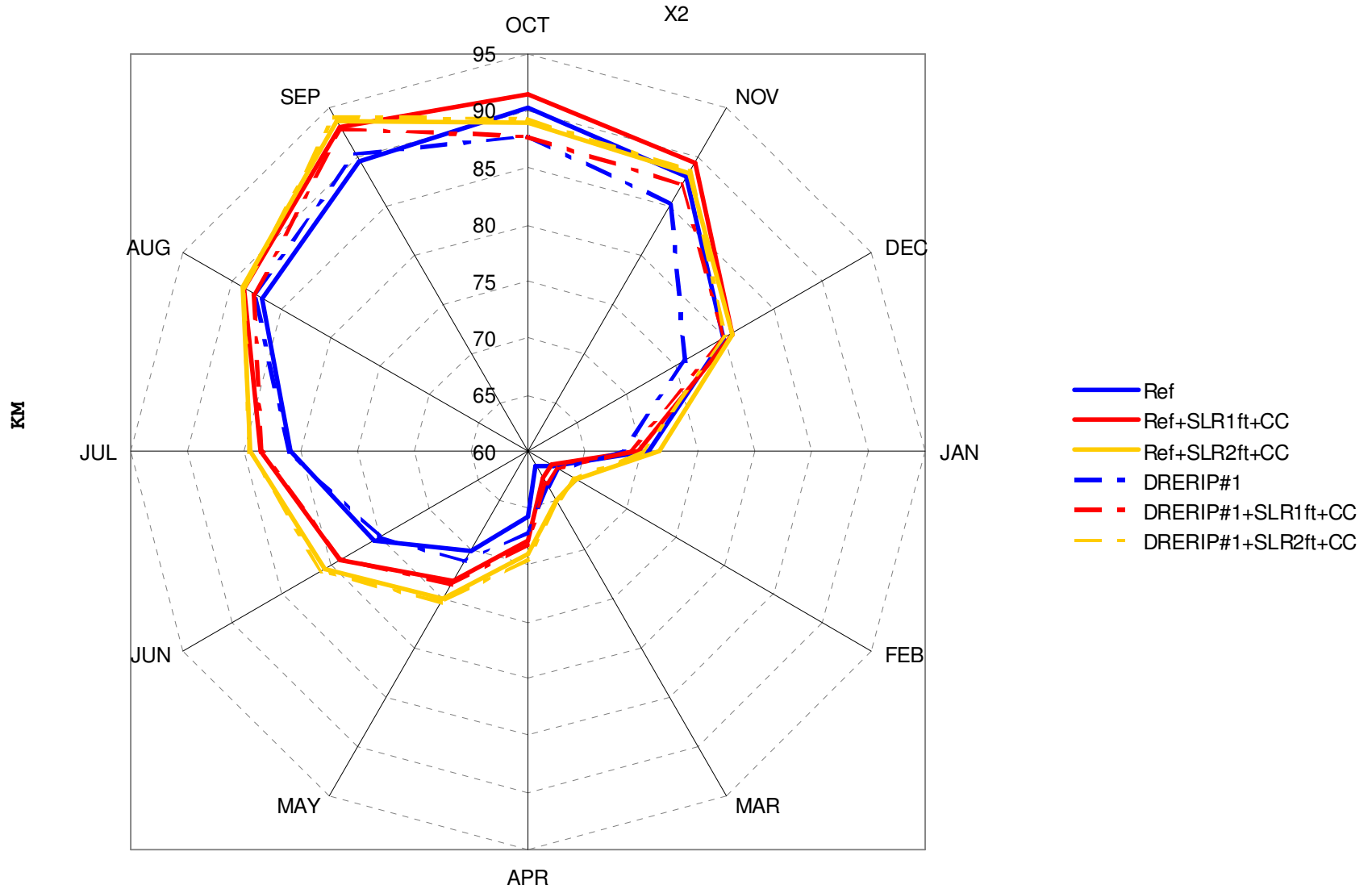
Multi Study Comparison - Long Term Monthly Average Results

Delta Outflow



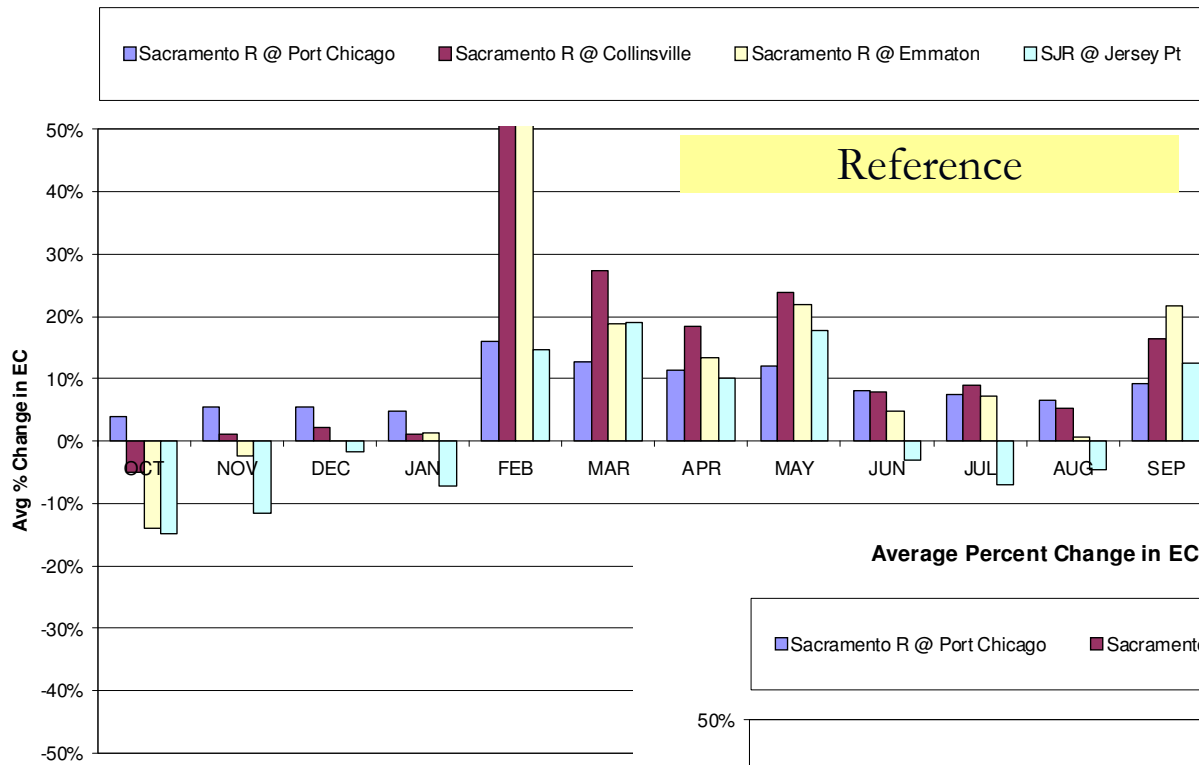
X2 Position Changes

Multi Study Comparison - Long Term Monthly Average Results

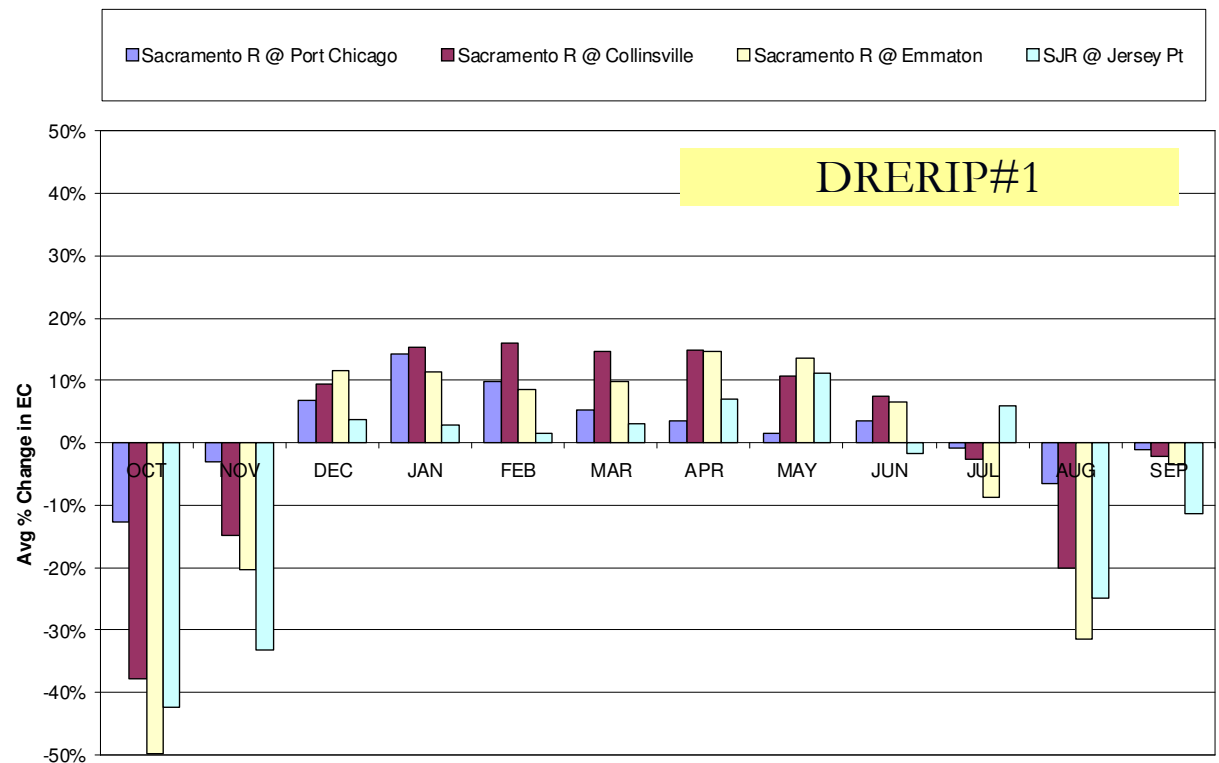


Western Delta Water Quality Changes

Average Percent Change in EC for Reference Study with Climate Change

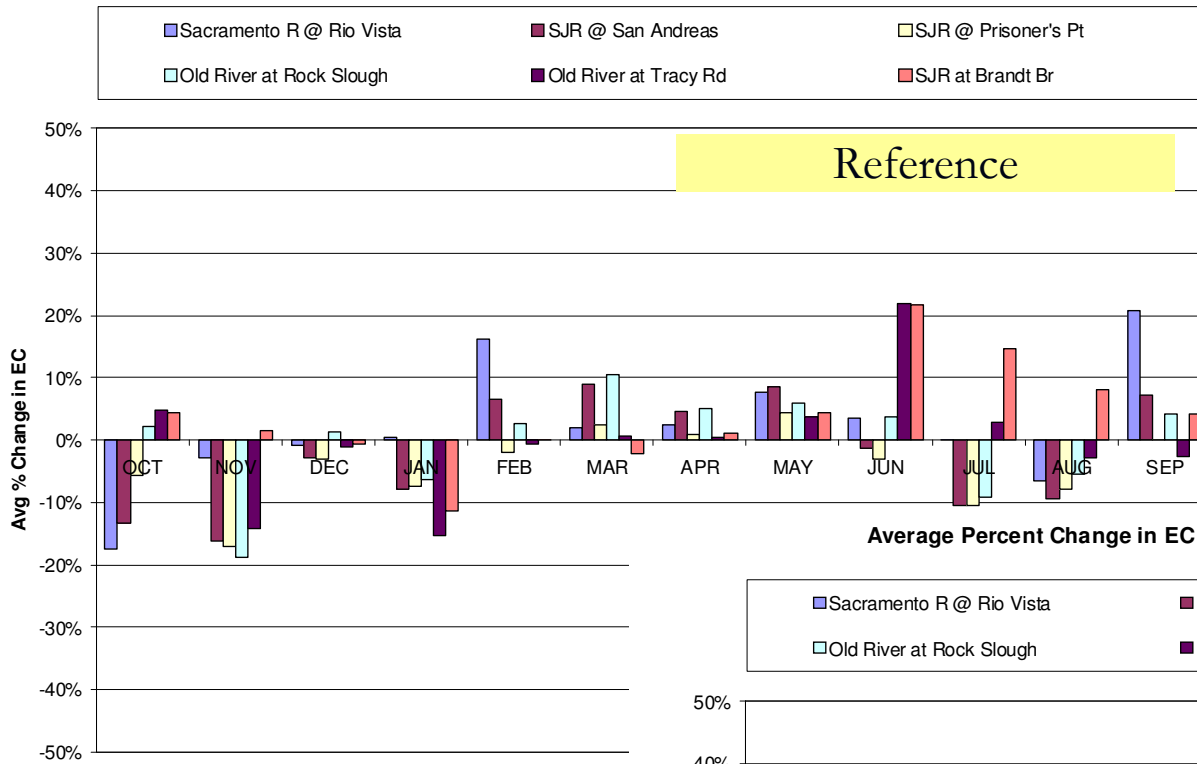


Average Percent Change in EC for "Scenario 1" Study with Climate Change

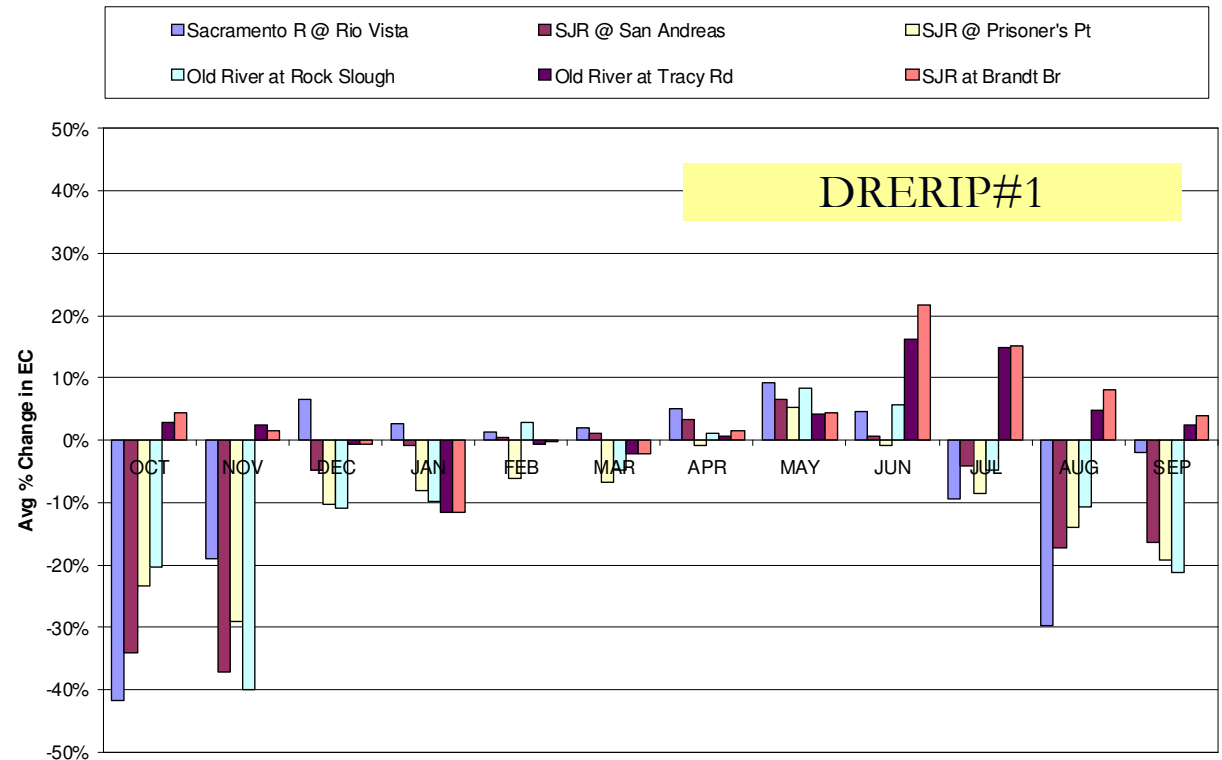


Water Quality Changes, Other Locations

Average Percent Change in EC for Reference Study with Climate Change



Average Percent Change in EC for "Scenario 1" Study with Climate Change



Summary of Preliminary Findings

- Climate change will have significant effect on timing of watershed runoff
 - Earlier runoff due to more rain/less snow and earlier snowmelt
 - Significant reductions in late spring and summer streamflows
- Upstream reservoir and cold water pool management will be severely challenged in the future
 - System vulnerable to shortages or loss of coldwater pool in 20-30% of the years
- Delta and export facilities may become (more) de-coupled from upstream operations
- Climate change is expected to reduce delivery reliability of the SWP and CVP, even under dual conveyance
- Salinity and X2 are expected to intrude with SLR, but higher outflows could manage the extent (at a high cost)

What Does this Mean for BDCP elements?

Delta Marsh Habitat

- Broader area of inundation, upland migration
- Deepening and increased predation pressures
- Salinity changes effects on vegetation and macro-invertebrate communities
- Changes to thermal refugia
- Changes to invasive species dynamics

Anadromous Fish Habitat

(upstream)

- Hydrograph and temperature changes
- Changes to spawning habitat/holding ponds
- Timing of spawning and outmigration (life cycle impacts)
- Increased floodplain inundation

Reservoir and Conveyance Facility Management

- Coldwater pool management
- Challenges to flood control operations
- Salinity changes and management
- Timing of water availability for export
- Changes to delivery reliability

Water Quality

- Increased salinity intrusion
- Levee system integrity, island flooding
- Changes to hydrodynamics and mixing
- Increased water temperatures
- Changes to dissolved oxygen
- Effects on water treatment and human health

BDCP Includes *Some* Climate Change Adaptation

- Climate change considered in project design
- Tidal marsh planned for sea level rise “accommodation”
 - sub-tidal, inter-tidal, and upland habitat
 - marsh believed to keep up with moderate rates of sea level rise
- Floodplain and “bypass” habitat for more variable hydrology
 - connectivity of tidal and riverine environments
- Principal conveyance moved out of major tidal zone
 - export water supplies protected against sea level rise and potential island flooding
 - improve water quality and protection against water quality shutdown

Some Recommendations for BDCP Planning

- BDCP should recognize that ...
 - changes due to climate change will be far larger than those of BDCP proposed project
 - BDCP by itself cannot provide enough flexibility to adapt to all the anticipated effects of climate change
 - major changes to the Central Valley system and Delta are inevitable
- BDCP can and should ...
 - anticipate futures under climate change
 - incorporate flexibility in both operations and habitat to accommodate anticipated changes
 - consider a risk assessment and adaptation framework

PRELIMINARY DRAFT—NOT FOR DISTRIBUTION

Climate Change Risk Assessment and Adaptation Framework



Climate Change Vulnerability & Risk Assessment

Identify Planning Areas & System

Sensitivity Analysis

Vulnerability Analysis

Risk Analysis

Develop Adaptation Strategies

- Identify planning area, system, and components
- How sensitive is the “system” to climate change? (*sensitivity*)
- How much climate change can the system accommodate? (*adaptive capacity & vulnerability*)
- What is the importance of the impact (consequence) and probability of occurrence (probability)? (*risk = consequence x probability*)
- Mechanisms to reduce risk (*adaptation*)

Next Steps

- Refine strategy to select representative climate futures
- Incorporate recent modifications to hydrologic indexing (primarily American River)
- Better integrate with 2-D and 3-D modeling efforts to account for changes to Bay and bathymetry
 - Improve treatment of SLR in DSM2
- Refine key policy issues for consideration