Drought – It is not just Hydrology

Impacts of Changing Delta Regulatory Requirements on CVP and SWP Delivery Capability

Sushil Arora, Ph.D., P.E.
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Outline

- Drought?
- Central Valley Hydrology
- CVP-SWP Water Resources System
- Delta Regulatory Requirements
- Modeling Results
Drought?

- **Hydrologic Drought**: Precipitation and Runoff less than Average

- **Drought For Water Users**: Shortage in water supply to meet demands
  - Annual Rainfall/Runoff
  - Surface and Groundwater Storage; Conveyance
  - Water Rights priorities
  - Regulatory Requirements
  - Water Supply Portfolio
Water Use and Supply Balances for Calif. South Coastal Region
Rim watershed

Sacramento River Rim Watershed

San Joaquin River Rim Watershed
Natural Hydrology Variations

Sacramento River

The Sacramento Four Rivers are: Sacramento River above Bend Bridge, near Red Bluff; Feather River inflow to Oroville; Yuba River at Smartville; American River inflow to Folsom
Natural Hydrology Variations

San Joaquin River

The San Joaquin Four Rivers are: Stanislaus River inflow to New Melones, Tuolumne River inflow to New Don Pedro, Merced River inflow to New Exchequer, San Joaquin River inflow to Millerton
Water Year Type Frequency

Histogram of Water Year Type
WY 1922-2009

Sacramento San Joaquin
Regulatory Requirements – Sacramento Basin

Sacramento River Minimum Flow below Keswick Dam (NMFS BO)

Clear Creek Minimum Flow below Whiskeytown Dam (NMFS BO)

Feather River Minimum Flow below Thermalito Afterbay (DWR, DFG Agreement)

Feather River Minimum Flow below Thermalito Diversion Dam (2006 Settlement Agreement)

Yuba River Minimum Flow below Daguerre Point Dam (SWRCB D-1644)

Navigation Control Point Flow Sacramento River at Wilkins Slough (NMFS BO)

Feather River Minimum Flow at Mouth (Verona)

American River Minimum Flow below Nimbus Dam (NMFS BO)

American River Minimum Flow at H Street Bridge (SWRCB D-893)
Regulatory Requirements – San Joaquin Basin

- Mokelumne River Minimum Flow below Camanche Dam (1996 Joint Settlement Agreement)
- Mokelumne River Minimum Flow below Woodbridge Diversion Dam (1996 Joint Settlement Agreement)
- Stanislaus River Minimum Flow below Goodwin Dam (NMFS BO)
- San Joaquin Minimum River Flow near Vernalis (NMFS BO)
- Tuolumne River Minimum Flow at La Grange Bridge (1995 Settlement Agreement)
- Merced River Minimum Flow below Crocker Huffman Dam (Cowell Agreement)
- San Joaquin River below Friant Dam (NMFS BO)
Ag. Water Demands

Sacramento Valley

- Acreage (acre): 1,048,561
- Applied Water (TAF): 3,464

- Rice: 536,180
- Other Crops: 3,100

San Joaquin Valley

- Acreage (acre): 1,754,758
- Applied Water (TAF): 5,524

- Rice: 1,754,758
- Other Crops: 5,524
WY 2000 (AN) Delta Water Balance

- Sacramento Valley: 84%
- San Joaquin Valley: 11%
- Eastside Streams: 5%
- In-Delta Use: 3%
- Exports: 25%
- Outflow: 72%
CVP - SWP Water Resources System

- Trinity: 2.5 maf
- Shasta: 4.5 maf
- Oroville: 3.5 maf
- Folsom: 1 maf
- SL SWP: 1.1 maf
- SL CVP: 0.97 maf
- Millerton: 2.4 maf
CVP and SWP service areas
### SWP and CVP Water Demands (Contracts)

<table>
<thead>
<tr>
<th>SWP Demands (TAF/yr)</th>
<th>Table A - Ag</th>
<th>Table A - M&amp;I</th>
<th>Non-SWP/WR Demand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOD Demands</td>
<td>-</td>
<td>37</td>
<td>1081</td>
<td>1118</td>
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<tr>
<td>SOD Demands</td>
<td>1017</td>
<td>3113</td>
<td>32</td>
<td>4162</td>
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</table>

<table>
<thead>
<tr>
<th>CVP Demands (TAF/yr)</th>
<th>Agriculture</th>
<th>Municipal &amp; Industrial</th>
<th>Exchange or Settlement</th>
<th>Refuge</th>
<th>Total</th>
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<tbody>
<tr>
<td>NOD Demands</td>
<td>480</td>
<td>541</td>
<td>2195</td>
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<td>SOD Demands</td>
<td>1963</td>
<td>148</td>
<td>875</td>
<td>305</td>
<td>3290</td>
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</tbody>
</table>
Salinity Standards
1. Emmaton
2. Jersey Point
3. Contra Costa PP#1
4. Collinsville
5. Chipps Island* 
6. Antioch*

*only used in D1485 studies
<table>
<thead>
<tr>
<th>Regulation Category</th>
<th>Decision 1485 (D1485)</th>
<th>Decision 1641 and CVPIA (b)(2) (D1641)</th>
<th>D 1641 with recent B0s RPAs</th>
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<tbody>
<tr>
<td>Rio Vista Min Flow</td>
<td>- Minimum flow at Rio Vista (flow varies by month)</td>
<td>- Minimum flow at Rio Vista (flow varies by month)</td>
<td>-D1641 standard</td>
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<tr>
<td>Delta Cross Channel</td>
<td>- # of gate days open or closed defined</td>
<td>- Revised Days open or closed defined</td>
<td>- D1641 standard</td>
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<tr>
<td>Salinity Standard</td>
<td>- Standard for 6 Stations (M&amp;I, Ag, and Fish)</td>
<td>- Standard for 4 Stations (M&amp;I, Ag, and Fish) - San Joaquin River Salinity</td>
<td>- D1641 standard</td>
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<tr>
<td>Export Constraints</td>
<td>- Pumping restriction May-June</td>
<td>- Export Inflow Ratio (35% from Feb – Jun and 65% from Jul-Jan)</td>
<td>- D1641 standard - Old and Middle river flow standard - Export cap based on Vernalis flow</td>
</tr>
<tr>
<td>Delta Outflow</td>
<td>- Minimum Delta outflow (standard varies by month)</td>
<td>- Revised Minimum Delta Outflow - X2 requirements (Spring)</td>
<td>- D1641 standard - Fall X2 requirements</td>
</tr>
</tbody>
</table>
Description of CalLite Model

- Central Valley Water Management Screening Model
- Simulation Period is 82 years (1922-2003)
- Flexible Graphical user interface
<table>
<thead>
<tr>
<th>Scenario</th>
<th>D1485</th>
<th>D1641</th>
<th>BO RPAs</th>
<th>Hydrology (Level of Development)</th>
<th>Demand (Current or Full)</th>
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<td>1</td>
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<td>Existing</td>
<td>SWP – Current CVP- Full Contract</td>
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<td>Future</td>
<td>SWP – Full Table A CVP- Full Contract</td>
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<td>Future</td>
<td>SWP – Full Table A CVP- Full Contract</td>
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</table>
SWP and CVP Dry Period Deliveries – Future LOD

Dry Periods: (1929-34, 1976-77, 1987-92)

SWP and CVP Average Annual Deliveries in Thousand Acre-Feet (TAF) for Dry Periods (1929-34, 1976-77, 1987-92)

- CVP SOD Deliveries
- SWP SOD Deliveries

<table>
<thead>
<tr>
<th>Simulation Scenarios</th>
<th>Deliveries (TAF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 4</td>
<td>SWP: 1552, CVP: 2053</td>
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<tr>
<td>Scenario 5</td>
<td>SWP: 1487, CVP: 1754</td>
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<tr>
<td>Scenario 6</td>
<td>SWP: 1350, CVP: 1231</td>
</tr>
</tbody>
</table>
SWP and CVP Dry Period Percent Deliveries—Future LOD (1929-34, 1976-77, 1987-92)

SWP and CVP Average Annual Deliveries as percentage of Maximum Demands for Dry Periods (1929-34, 1976-77, 1987-92)

- CVP SOD Deliveries
- SWP SOD Deliveries

Deliveries (TAF)

Simulation Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>CVP Deliveries</th>
<th>SWP Deliveries</th>
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</thead>
<tbody>
<tr>
<td>Scenario 4</td>
<td>47%</td>
<td>50%</td>
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<tr>
<td>Scenario 5</td>
<td>45%</td>
<td>42%</td>
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<tr>
<td>Scenario 6</td>
<td>41%</td>
<td>30%</td>
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</table>
SWP and CVP Long Term Deliveries – Future LOD

SWP and CVP Average Annual Deliveries in Thousand Acre-Feet (TAF) for Long Term (1922-2002)

- CVP SOD Deliveries
- SWP SOD Deliveries

<table>
<thead>
<tr>
<th>Simulation Scenarios</th>
<th>CVP SOD Deliveries</th>
<th>SWP SOD Deliveries</th>
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<tbody>
<tr>
<td>Scenario 4</td>
<td>2517</td>
<td>3355</td>
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<td>Scenario 5</td>
<td>2442</td>
<td>3240</td>
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<td>Scenario 6</td>
<td>2196</td>
<td>2536</td>
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</table>
SWP and CVP Long Term Percent Deliveries – Future LOD

SWP and CVP Average Annual Deliveries in Thousand Acre-Feet (TAF) for Long Term (1922-2002)

Simulation Scenarios

- Scenario 4: 77% CVP SOD Deliveries, 81% SWP SOD Deliveries
- Scenario 5: 74% CVP SOD Deliveries, 78% SWP SOD Deliveries
- Scenario 6: 67% CVP SOD Deliveries, 61% SWP SOD Deliveries
Exceedance Annual SWP Deliveries in Thousand Acre-Feet (TAF) for Long Term (1922-2002)

Percent at or above

0 100% 80% 60% 40% 20% 0%

Deliveries (TAF)
0 500 1000 1500 2000 2500 3000 3500 4000 4500

Scenario 4
Scenario 5
Scenario 6
Historical SWP Annual Allocations
Percent of Request for 2000-2012

SWP Allocation as Percent of Request

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<td>AN</td>
<td>90%</td>
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</table>

Time (year and water year type)
Thank you!!
SWP and CVP Dry Period Deliveries – Current LOD

Dry Periods: (1929-34, 76-77, 87-92)

SWP and CVP Average Annual Deliveries in Thousand Acre-Feet (TAF) for Dry Periods (1929-34, 1976-77, 1987-92)

Simulation Scenarios

- Scenario 1: CVP SOD Deliveries - 2041 TAF, SWP SOD Deliveries - 1626 TAF
- Scenario 2: CVP SOD Deliveries - 1816 TAF, SWP SOD Deliveries - 1538 TAF
- Scenario 3: CVP SOD Deliveries - 1445 TAF, SWP SOD Deliveries - 1361 TAF
SWP and CVP Dry Period Percent Deliveries—Current LOD (1929-34, 1976-77, 1987-92)

SWP and CVP Average Annual Deliveries as percentage of Maximum Demands for Dry Periods (1929-34, 1976-77, 1987-92)

- **Scenario 1**: SWP 49%, CVP 52%
- **Scenario 2**: SWP 47%, CVP 46%
- **Scenario 3**: SWP 44%, CVP 34%
SWP and CVP Long Term Percent Deliveries – Current LOD

SWP and CVP Average Annual Deliveries as percentage of Maximum Demands for Long Term (1922-2002)

- Scenario 1: CVP SOD Deliveries = 79%, SWP SOD Deliveries = 82%
- Scenario 2: CVP SOD Deliveries = 76%, SWP SOD Deliveries = 80%
- Scenario 3: CVP SOD Deliveries = 68%, SWP SOD Deliveries = 67%
SWP Long Term Deliveries – Current LOD

Exceedance Annual SWP Deliveries in Thousand Acre-Feet (TAF) for Long Term (1922-2002)
CVP Long Term Deliveries – Current LOD

Exceedance Annual CVP Deliveries in Thousand Acre-Feet (TAF) for Long Term (1922-2002)

Deliveries (TAF)

Percent at or above

Scenario 1
Scenario 2
Scenario 3