Sacramento River
Ecological Flow Thresholds for Salmonids Workshop

Brycen Swart
September 29, 2016
Shasta Division
Central Valley Project
Regulatory Context

- 2009
  - Biological Opinion on the CVP/SWP Long-term Water Operations (OCAP)
  - Jeopardy Determination
  - Shasta Division RPA actions address storage requirements, temperature compliance, drought contingencies, and re-introduction but not flows
- 2016
  - Shasta Division RPA Adjustment – RPA actions are not avoiding jeopardy
  - CVP/SWP Long-term Operations Re-initiation
  - SWRCB – Bay-Delta Water Quality Control Plan
## Current Flow Management

### Minimum Flow Requirements

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Critically Dry</td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Water Year Type</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 1–February 28(29)</td>
<td>2,600</td>
<td>2,000</td>
<td>3,250</td>
</tr>
<tr>
<td>March 1–March 31</td>
<td>2,300</td>
<td>2,300</td>
<td>2,300</td>
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<tr>
<td>April 1–April 30</td>
<td>2,300</td>
<td>2,300</td>
<td>2,300</td>
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<tr>
<td>May 1–August 31</td>
<td>2,300</td>
<td>2,300</td>
<td>2,300</td>
</tr>
<tr>
<td>September 1–September 30</td>
<td>3,900</td>
<td>2,800</td>
<td>3,250</td>
</tr>
<tr>
<td>October 1–November 30</td>
<td>3,900</td>
<td>2,800</td>
<td>3,250</td>
</tr>
<tr>
<td>December 1–December 31</td>
<td>2,600</td>
<td>2,000</td>
<td>3,250</td>
</tr>
</tbody>
</table>
Flow Regime Approach

Mimic “natural”, climatically-driven variability of flows from year to year and from season to season

- Magnitude
- Timing
- Duration
- Frequency
- Rate of change
Principles for Flow Regime Approach

- Flow determines the extent and type of physical habitat, which in turn determines the types of living organisms in that habitat.
- Aquatic species have evolved in such a way as to be well adapted to the natural flow regime to which they have been historically exposed.
- Maintenance of natural patterns of high flows, low flows and flow variation is essential to the viability of native riverine species.
- The alteration of flow regimes contributes to the invasion and success of exotic (non-native) species in rivers.

(Bunn and Arthington, 2002)
Implementing Flow Regime Approach

- Collect flow data and analyze them.
- If there is a period of time when flows were measured before major human modifications occurred, that time period is used to set the baseline or natural, unmanaged flow conditions.
- If no such data exists, use other data (e.g., similar unimpacted rivers or unimpaired flow) to establish historic conditions.
- Set recommended flows throughout the year, providing flow recommendations for each hydrologic season (e.g. low flow, snowmelt, rainy season).
Pre-Dam Natural Flow

Winter High Flow

Fall Low Flow

Spring Moderate Flow

Summer Low Flow

NRDC-48
Median Monthly Flows

- Period 1 (1892-1937)
- Period 2 (1946-1959)
- Period 3 (1960-1993)
- Period 4 (1994-2014)
# Changes in Flood Flows

<table>
<thead>
<tr>
<th>Period</th>
<th>1.5-Year Flood</th>
<th>2-Year Flood</th>
<th>5-Year Flood</th>
<th>10-Year Flood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period 1 (1892-1937)</td>
<td>89730</td>
<td>130000</td>
<td>153000</td>
<td>206000</td>
</tr>
<tr>
<td>Period 2 (1946-1959)</td>
<td>54600</td>
<td>85700</td>
<td>97400</td>
<td>125000</td>
</tr>
<tr>
<td>Period 3 (1960-1993)</td>
<td>50500</td>
<td>77500</td>
<td>101000</td>
<td>123000</td>
</tr>
<tr>
<td>Period 4 (1994-2014)</td>
<td>41400</td>
<td>73200</td>
<td>88800</td>
<td>105000</td>
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<tr>
<td>% Reduction (P1 and P2)</td>
<td>39%</td>
<td>34%</td>
<td>36%</td>
<td>39%</td>
</tr>
<tr>
<td>% Reduction (P1 and P3)</td>
<td>44%</td>
<td>40%</td>
<td>34%</td>
<td>40%</td>
</tr>
<tr>
<td>% Reduction (P1 and P4)</td>
<td>54%</td>
<td>44%</td>
<td>42%</td>
<td>49%</td>
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# Changes in Spring Pulse Flows

<table>
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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Magnitude (cfs)</td>
<td>20200</td>
<td>14800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration (day)</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timing (day of year)</td>
<td>100</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency (per year)</td>
<td>1.5</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Rise rate (cfs/day)</td>
<td>4650</td>
<td>2715</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall rate (cfs/day)</td>
<td>-1377</td>
<td>-2788</td>
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# Environmental Thresholds and Requirements

<table>
<thead>
<tr>
<th>Threshold Description</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Timing</th>
<th>Frequency</th>
<th>Source</th>
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<tbody>
<tr>
<td>Bed Mobilization</td>
<td>24,000 - 120,000</td>
<td>12 hour peak flow</td>
<td>Between Feb 20 - March 20</td>
<td>3 to 4 years</td>
<td>Cain 2008, DWR 2001, Kondolf 2000, Stillwater 2006</td>
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<tr>
<td>Bank Erosion and Channel Migration</td>
<td>15,000 - 60,000</td>
<td>?</td>
<td>Prior to late March</td>
<td>2 to 4 years</td>
<td>Stillwater 2007, Larsen 2007</td>
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<tr>
<td>Floodplain Inundation and Rearing Habitat Flows</td>
<td>&gt;25,000</td>
<td>30 - 60 days</td>
<td>Feb 15 to April 30</td>
<td>Dry to Wet Water Year Types</td>
<td>Harrell 2008, DWR 2008</td>
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<tr>
<td>Riparian Flows</td>
<td>23,000 - 30,000</td>
<td>72 day recession period</td>
<td>April to May</td>
<td>Above Normal and Wet Years</td>
<td>Roberts 2003, Kondolf 2007, Cain 2008</td>
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## Potential Flow Recommendations

<table>
<thead>
<tr>
<th>Water Year Type</th>
<th>Timing</th>
<th>Critical</th>
<th>Dry</th>
<th>Below Normal</th>
<th>Above Normal</th>
<th>Wet</th>
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<tbody>
<tr>
<td>Bed Mobilization</td>
<td>Mid Feb – Mid Mar</td>
<td>35,000</td>
<td>65,000</td>
<td>85,000</td>
<td>105,000</td>
<td></td>
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<tr>
<td>Floodplain Inundation</td>
<td>Feb - Apr (45 days)</td>
<td>25,000</td>
<td>35,000</td>
<td>45,000</td>
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<tr>
<td>Riparian Establishment Flow</td>
<td>Apr</td>
<td>23,000</td>
<td>37,000</td>
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<tr>
<td>Fall Base Flow</td>
<td>Sep - Nov</td>
<td>5,250</td>
<td>5,250</td>
<td>5,250</td>
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<tr>
<td>Winter Base Flow</td>
<td>Dec - Feb</td>
<td>4,500</td>
<td>6,000</td>
<td>6,500</td>
<td>7,000</td>
<td>8,000</td>
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<tr>
<td>Spring Base Flow</td>
<td>Mar - May</td>
<td>10,000</td>
<td>12,000</td>
<td>12,500</td>
<td>14,000</td>
<td>14,000</td>
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<tr>
<td>Summer Base Flow</td>
<td>Jun - Aug</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
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</tbody>
</table>
Next Steps

- Incorporate regression analysis of salmonid abundance with instream flow
- Refine flow recommendations
- CALSIM, SRWQM, and RAFT modeling
Validation

Hydroclimate Conditions

Hydrology Models
WIC

Reservoir Models
CE-QUAL-W2

Hydrodynamics Models
HecRas, FaSTMECH

Temperature Models
RAFT, SRWQM

Physical Models

Egg Mortality Models
DEB

Life Cycle Model
CVC-LCM

Biological Models

User Interface
Web site

Decision Support Tools

Reservoir Operations

Hydroclimate Scenarios

Applications

Operations and Planning
Water and Fisheries Managers

RPA Management Actions
OCAP and BDCP

Biological Data
Redd and Carcass Surveys

Physical Data
Temperature and flow loggers

Field Data

Retrospective/validation

Historical Climate Data
PRISM
1915-2010

Meteorological Models
COAMPS
1-7 Day

Historical Resampling
DWR Res Inflow, Met
30 days – 1 Year

Climate Scenarios
IPCC Models
Decades

Operations

Planning

NRDC-48
Thanks! Any Questions?