

# RECLAMATION

*Managing Water in the West*

***2015 Sacramento River***

***Temperature Operations***



U.S. Department of the Interior  
Bureau of Reclamation

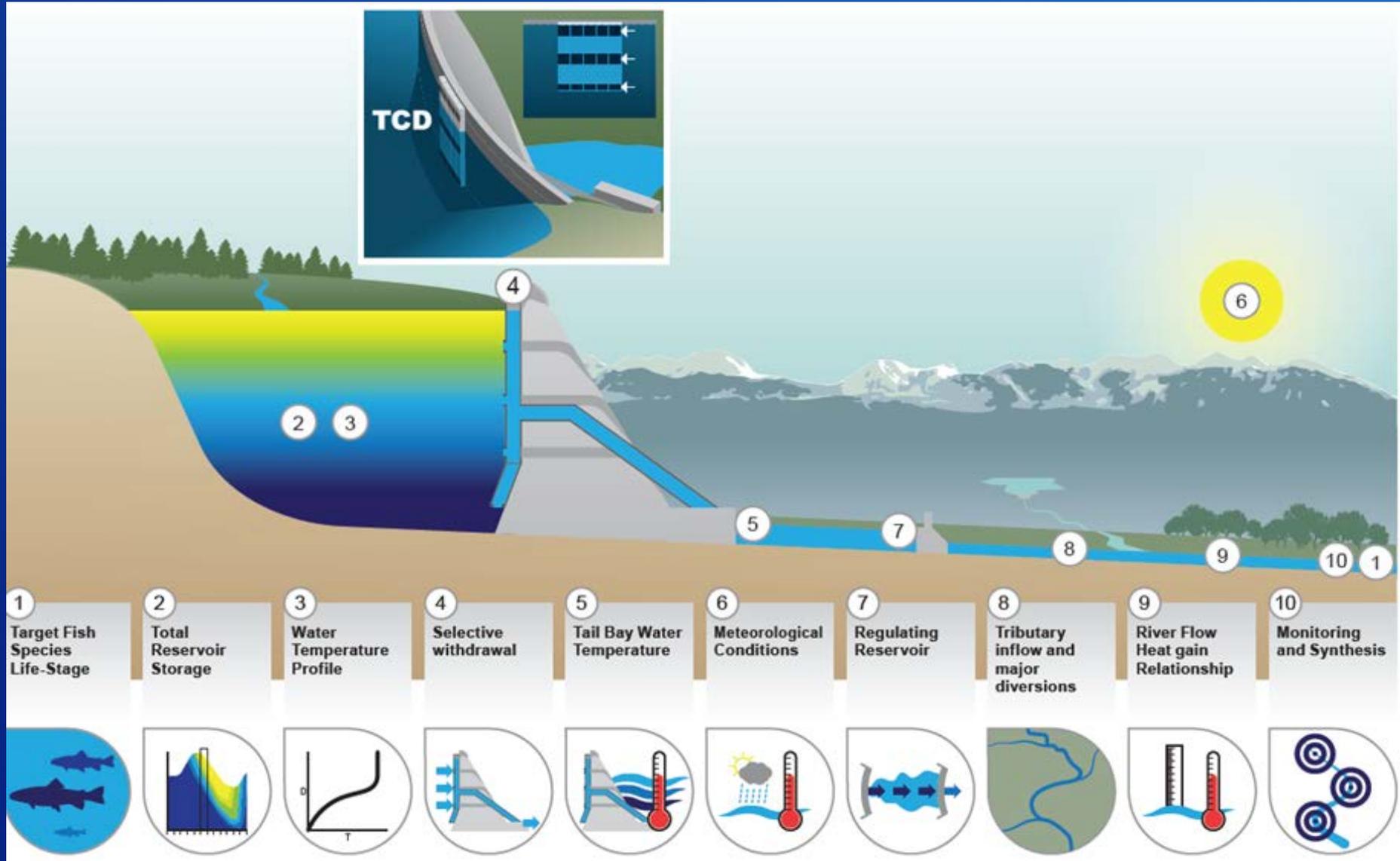
# Topics

- Elements of Temperature Management
- USBR Seasonal Temperature Model
- 2015 Temperature Operations

# Water Temperature Challenges

- Annual variability in hydrology and meteorology
- System wide operations and variable demands
- Unforeseen events/circumstances

# Elements of Temperature Management



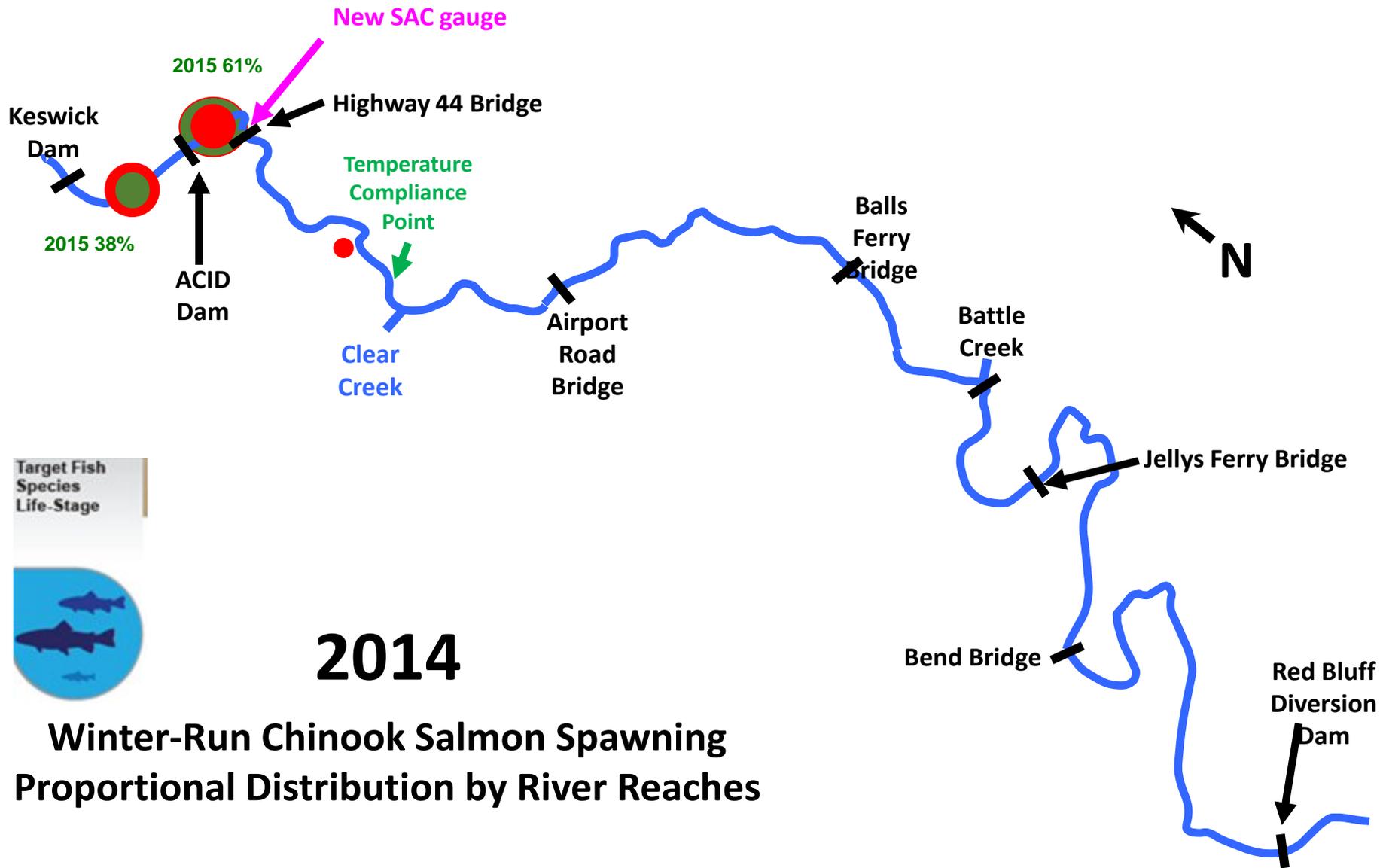


# Life-Stage

- Pre-spawning
- Egg incubation
- Alevin production
- Red Bluff Juvenile Passage

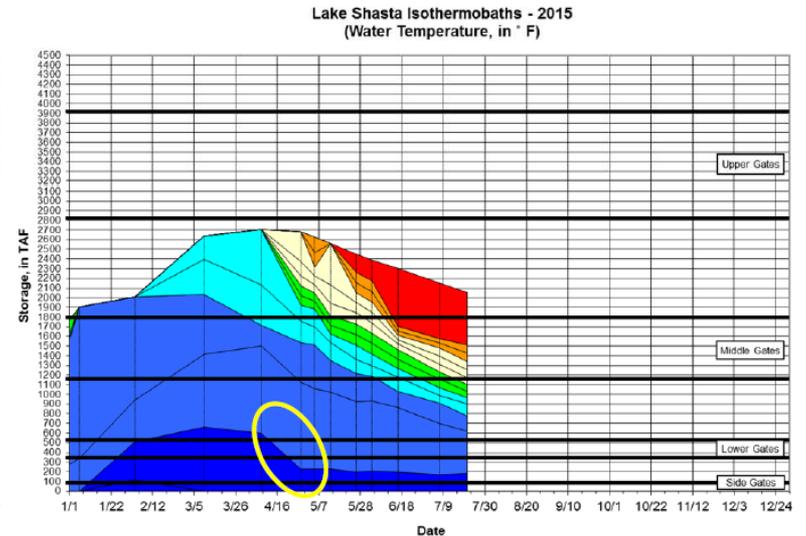
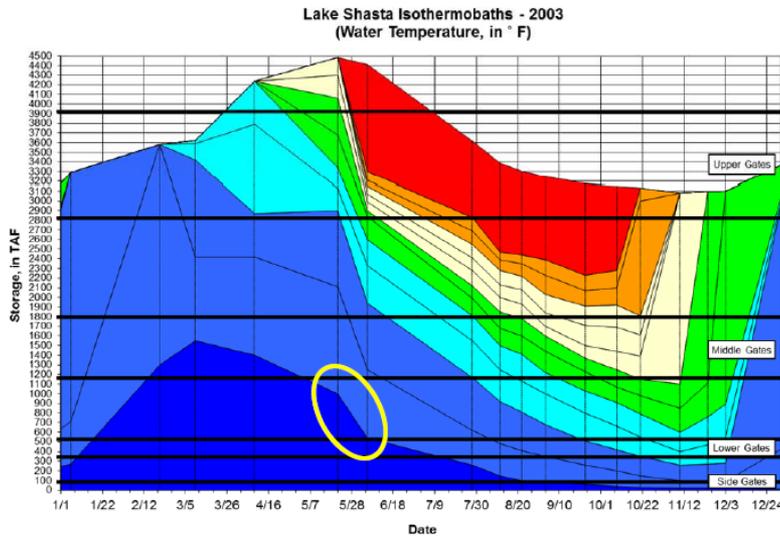
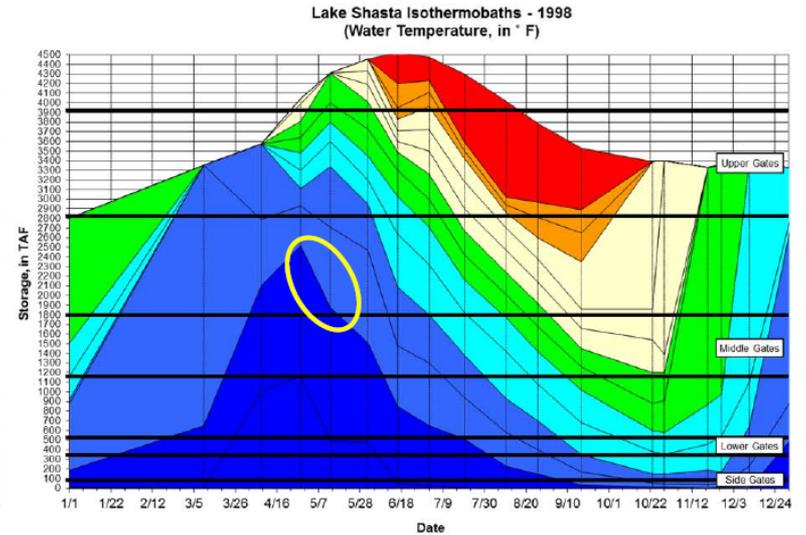
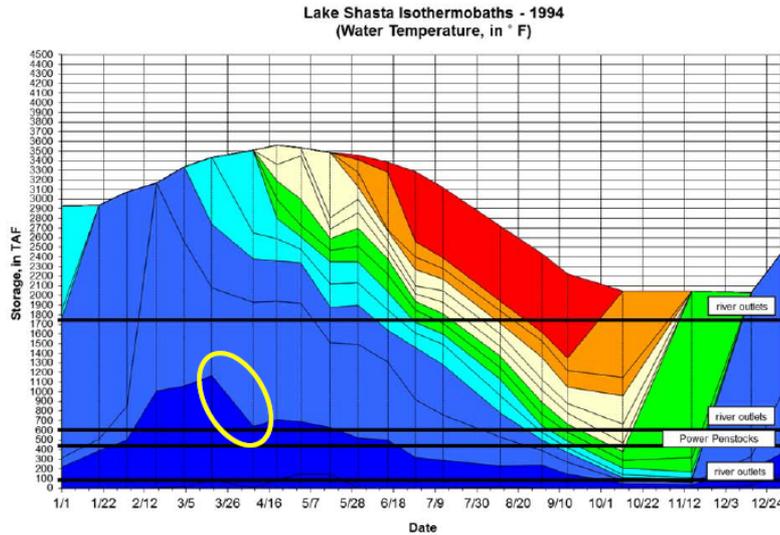
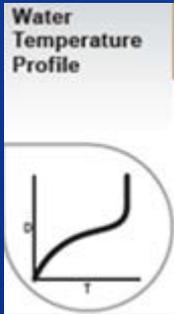


# Real Time Winter Run Monitoring



Winter-Run Chinook Salmon Spawning Proportional Distribution by River Reaches

# Uncertainties -- Initial Shasta Reservoir Temperature



# The Variables

*Significantly Affect Temperature Management Planning and Performance*

- **Hydrological:**

Overall basin runoff, Distribution among Basins, Distribution over time, Flood inflows.

- **Climatological:**

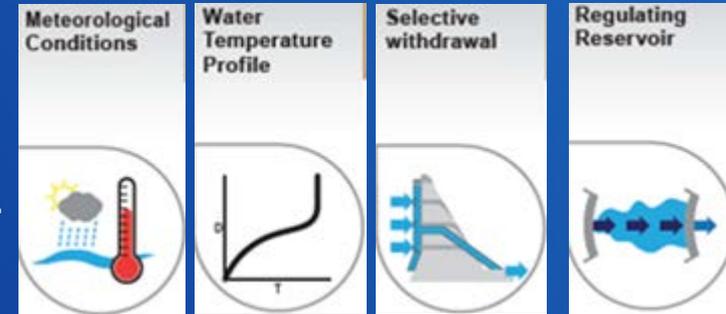
Temperature of Reservoir Inflows, Atmospheric Temps, Meteorological Anomalies.

- **Limnological:**

Stratification Cycle, Temperature Profile anomalies.

- **Operational:**

CVP Demands and Responsibilities that constrain storage and release. Performance of Shasta TCD. Maintaining “Thermal Connection” between Trinity and Sacramento Rivers.

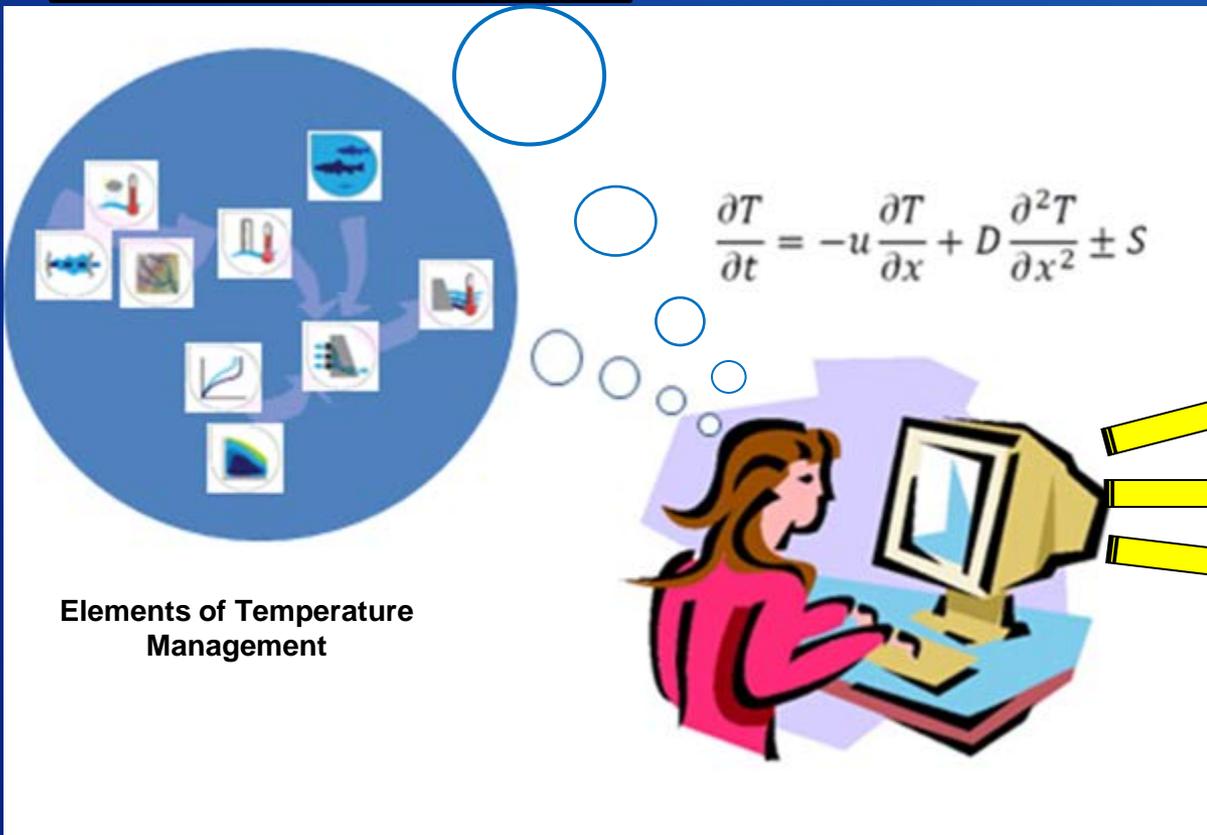


# Use of USBR Seasonal Model

- Project out where compliance point can be met throughout the season with the cold water resource available for the season
- Reasonably projected TCD gate timing and configuration
- Continuous Model updating



Operational Scenario A  
Operational Scenario B  
Operational Scenario C



**Risk-Uncertainty**  
**Tradeoffs**

Outcome A  
Outcome B  
Outcome C

# Temperature Model Expectation

## The Model Can

- Project if a temperature strategy can be sustained through the season
- Major TCD milestone triggers
- Estimate temperature trends
- Project out a monthly average temperature estimate
- When updated- gives progress of the previous simulation

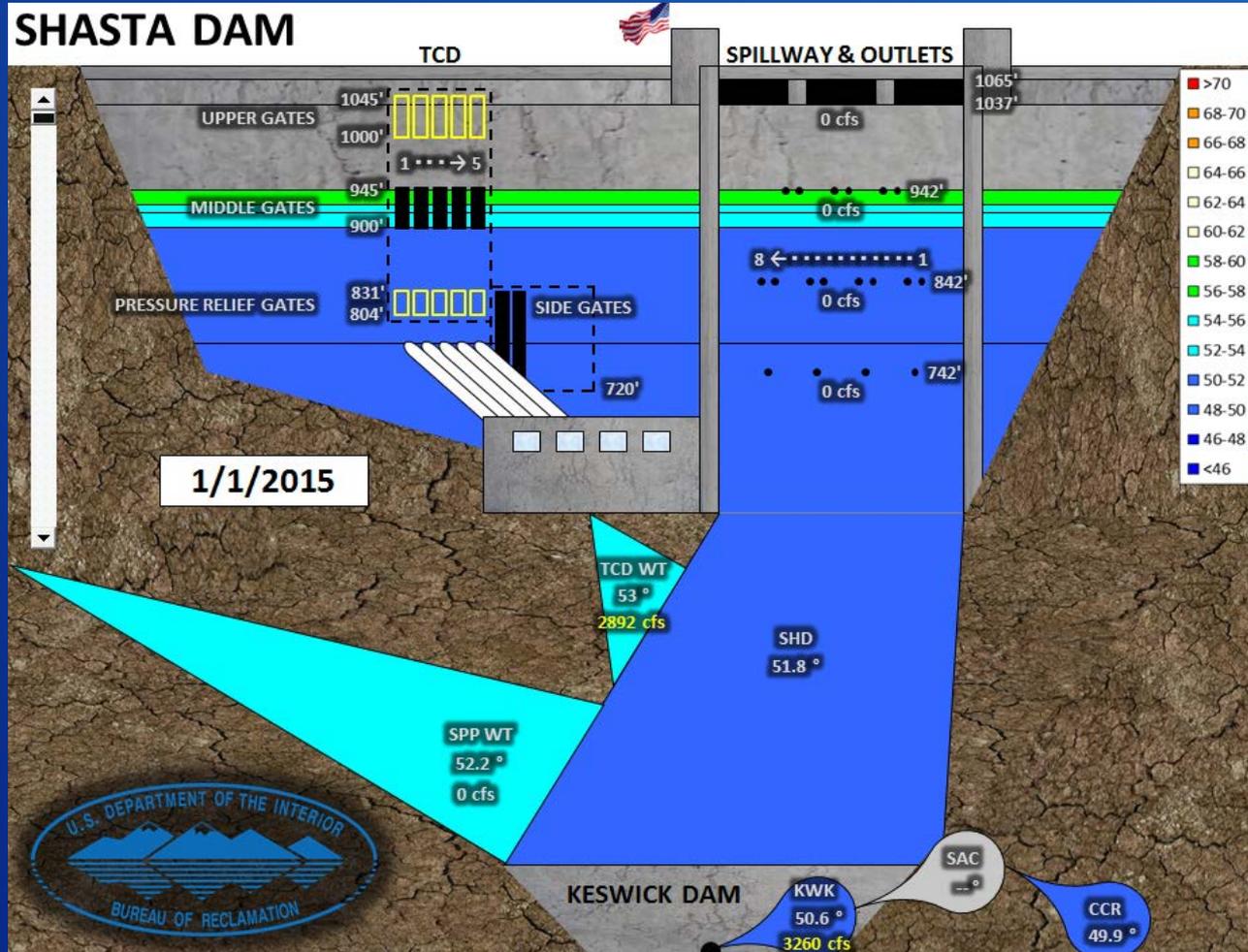
## The Model Cannot

- Be used for real time (day to day) operations
- Capture all the variability of the factors that affect river temperature
- Predict precise daily river temperature
- Override the reservoir release patterns

# 2015 Sacramento River Temperature Management

- 2015 Operations
- Modifications made in 2015
- Model projections compared to actual

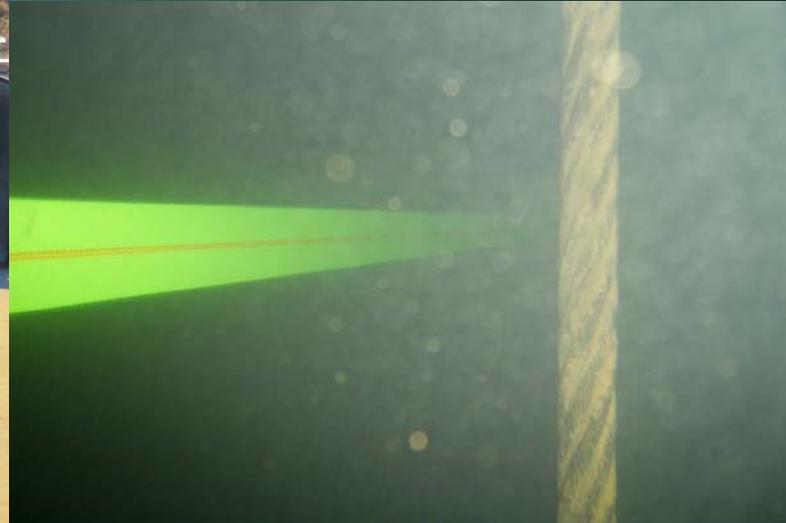
# 2015 TCD OPS



# Modifications in 2015

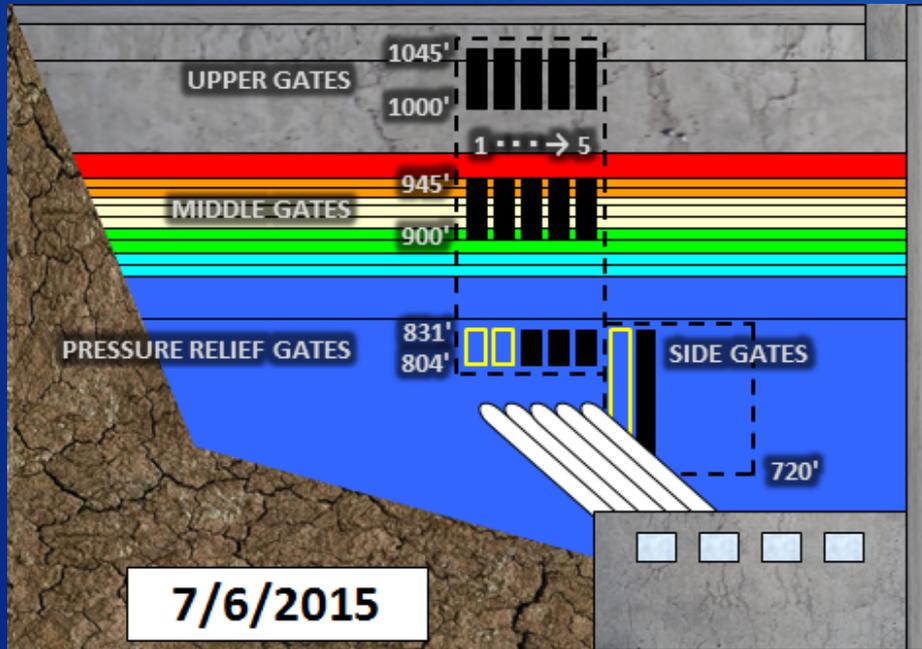
- KWK to CCR temperature adjustment
- 10% L3MTO (*warmer outlook for the temperature season*)
- New temperature gauge (SAC) right above HWY 44
- Target where the majority of Winter Run REDDS were  
(*Target 57 degree and not to exceed 58 degree at CCR*)
- Target 58 degree then 57 degree when spawning began
- Coordinate closely with the Settlement Contractors demands
- “Warm water” bypass
- Install TCD Curtain (*reduces warm water blending in the TCD*)

# TCD Curtain

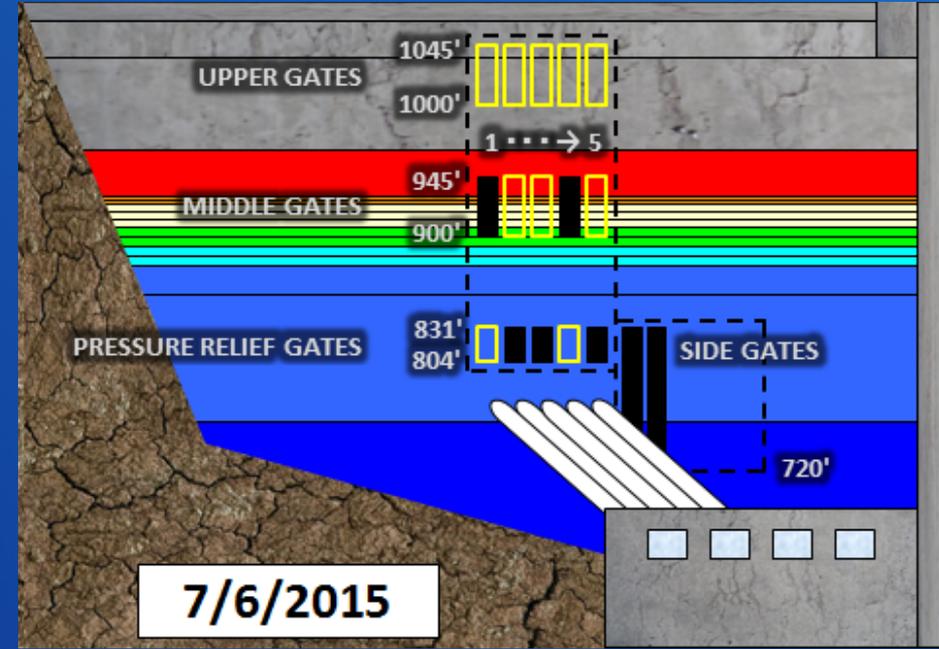


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# First Side Gate Opened (Per Model Run)



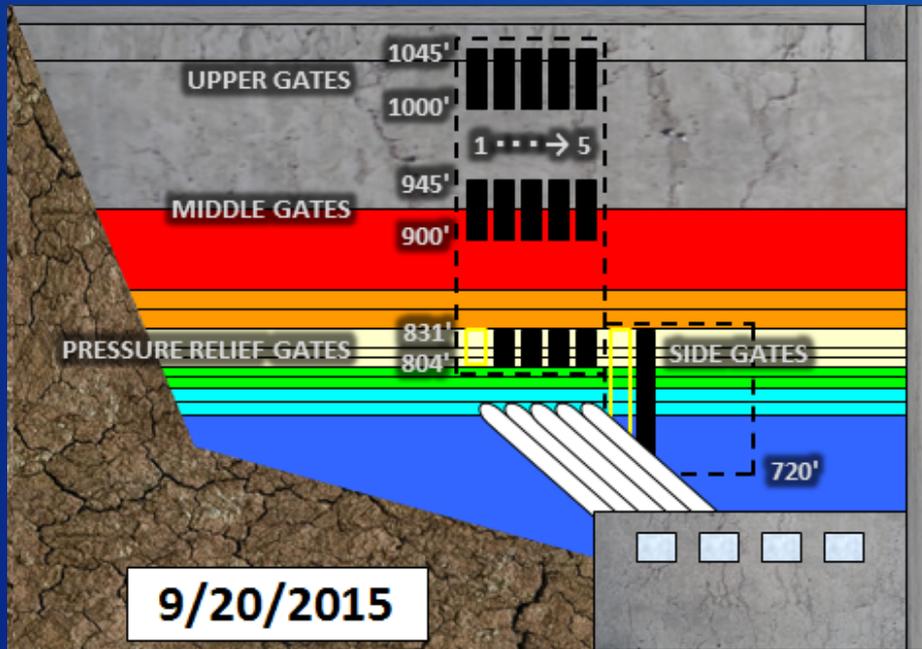
June 16<sup>th</sup> 10% model run results



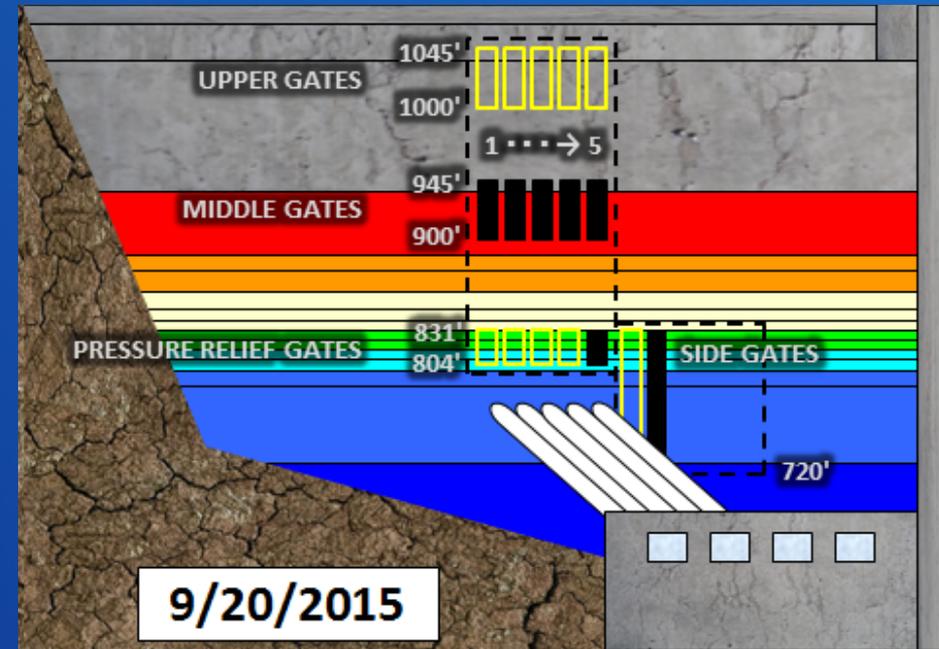
Actual Operations

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# Primary Reliance of Side Gate (Per Model Run)



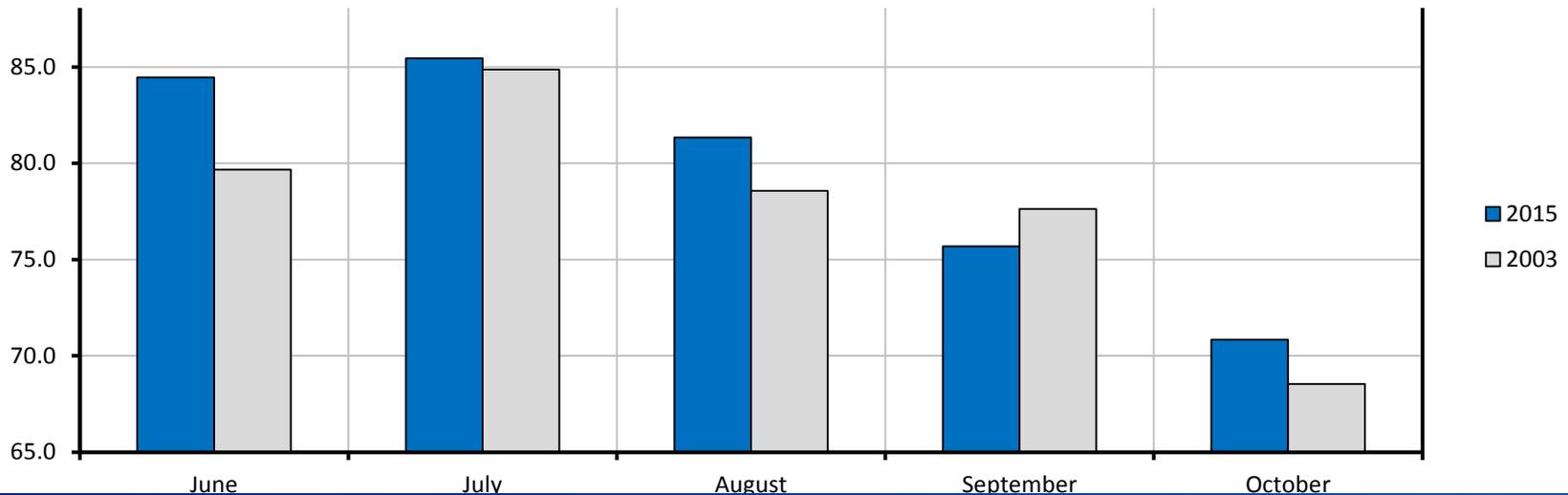
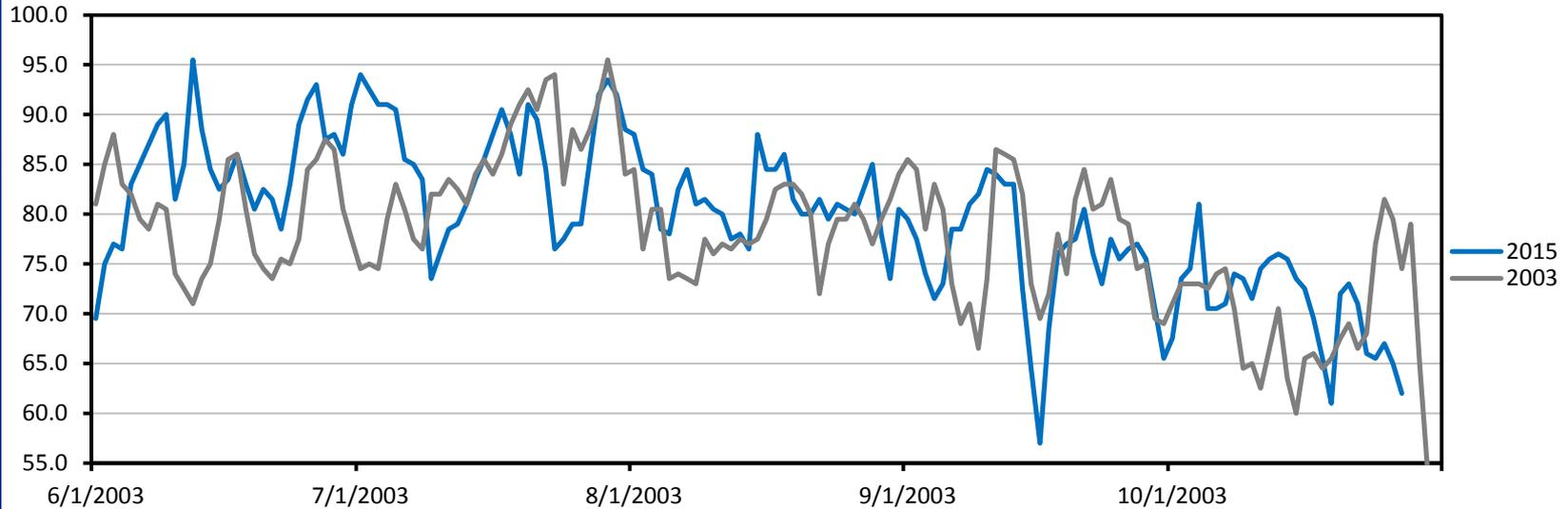
September 1<sup>st</sup> 10% model run results



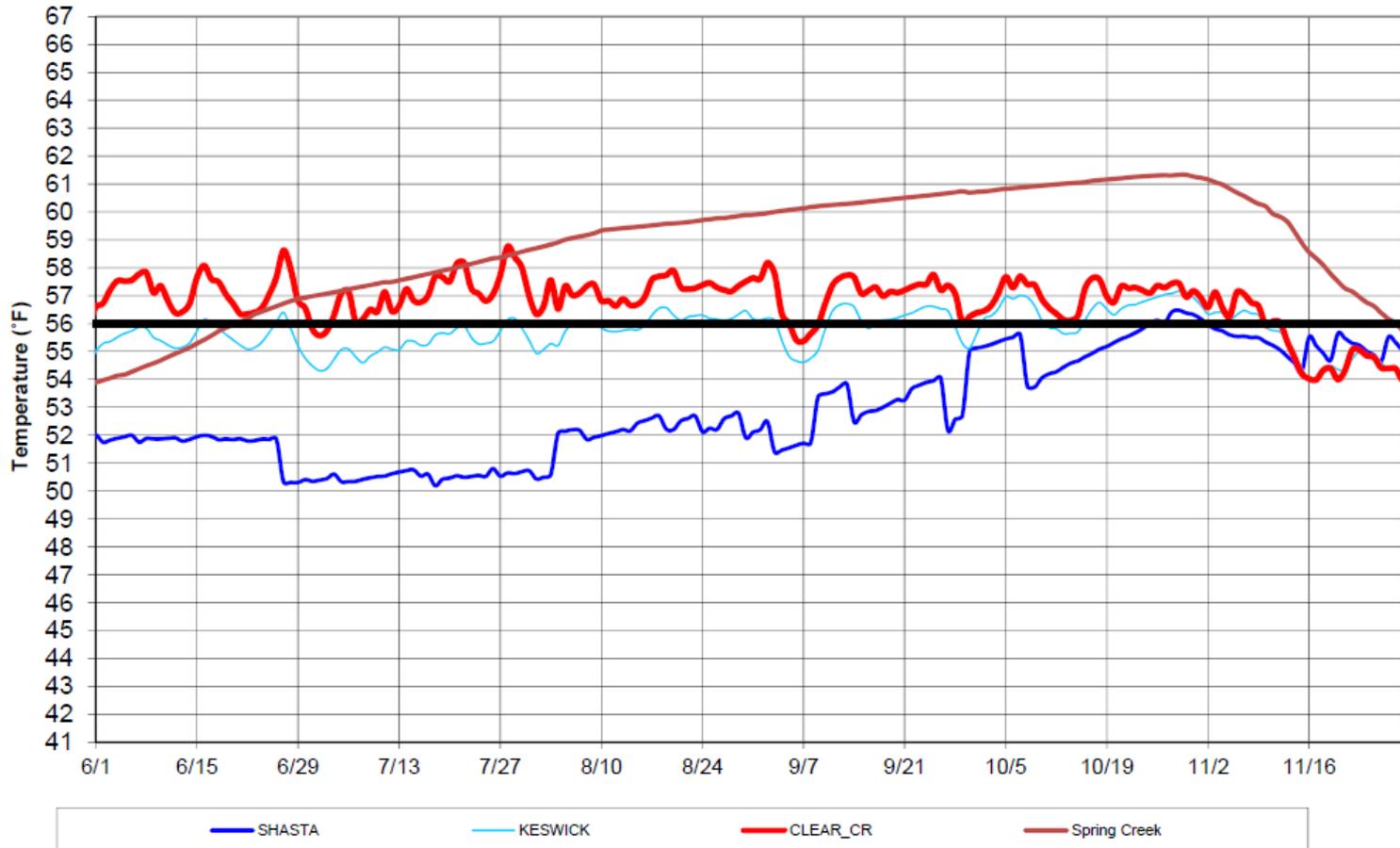
Actual Operations

# Redding Temperature

## Observed Mean Temperature (°F)

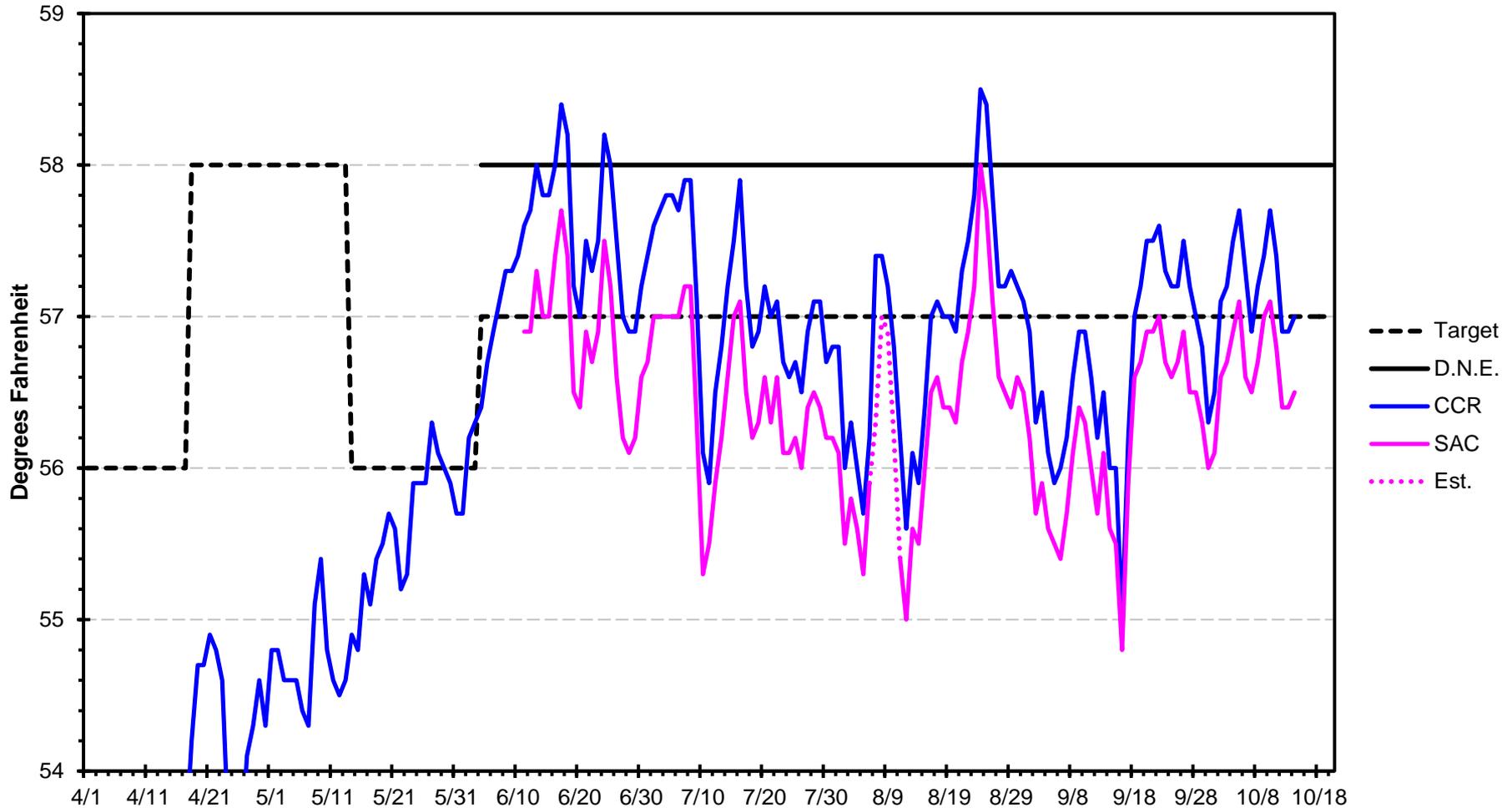


Sacramento River Modeled Temperature  
2015 May 90%-Water Ops Outlook - 10% L3MTO (May)  
Approximately 57 degree at CCR - Kes at 7,250 cfs



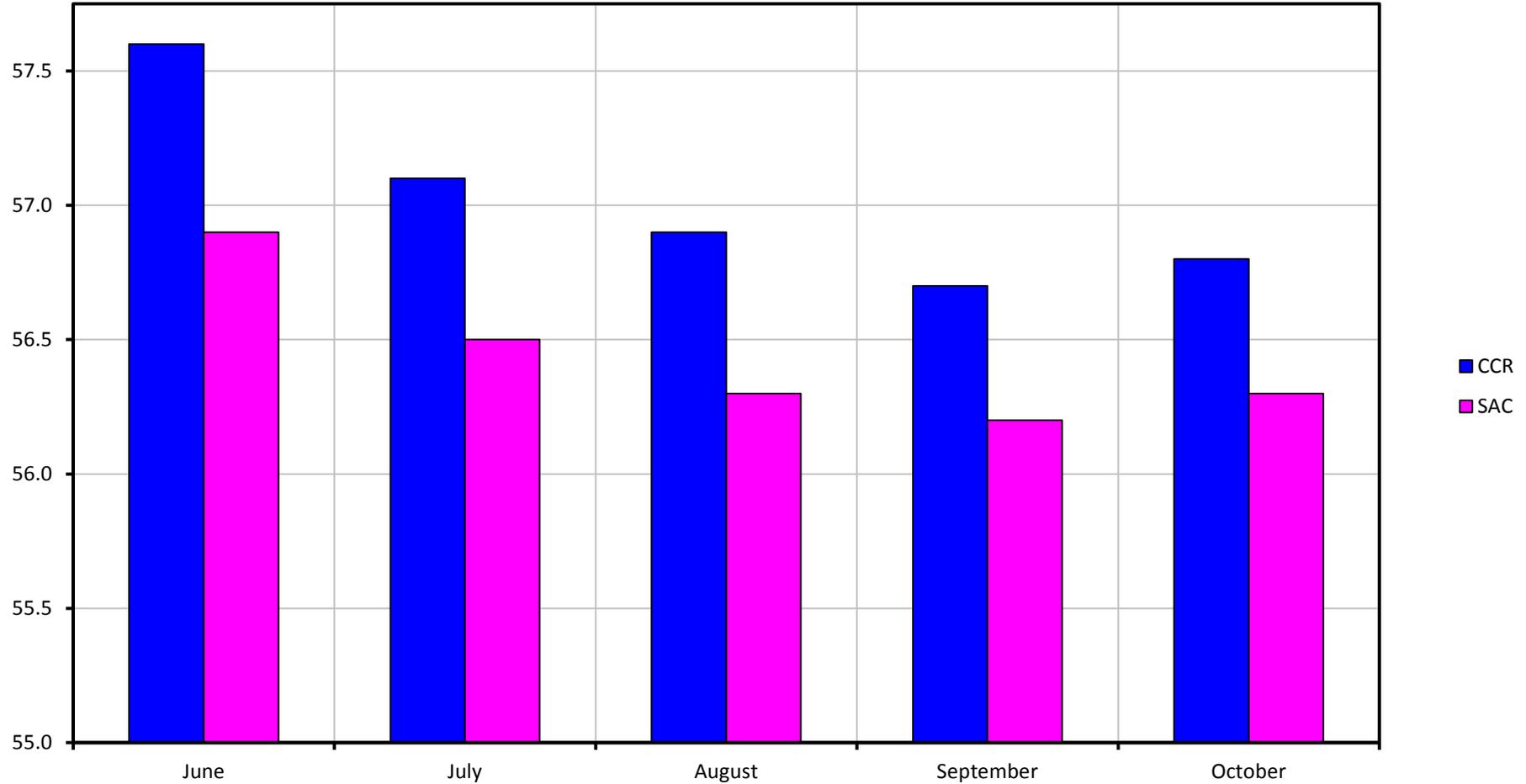
6/25/2015

# SAC and CCR Temperature

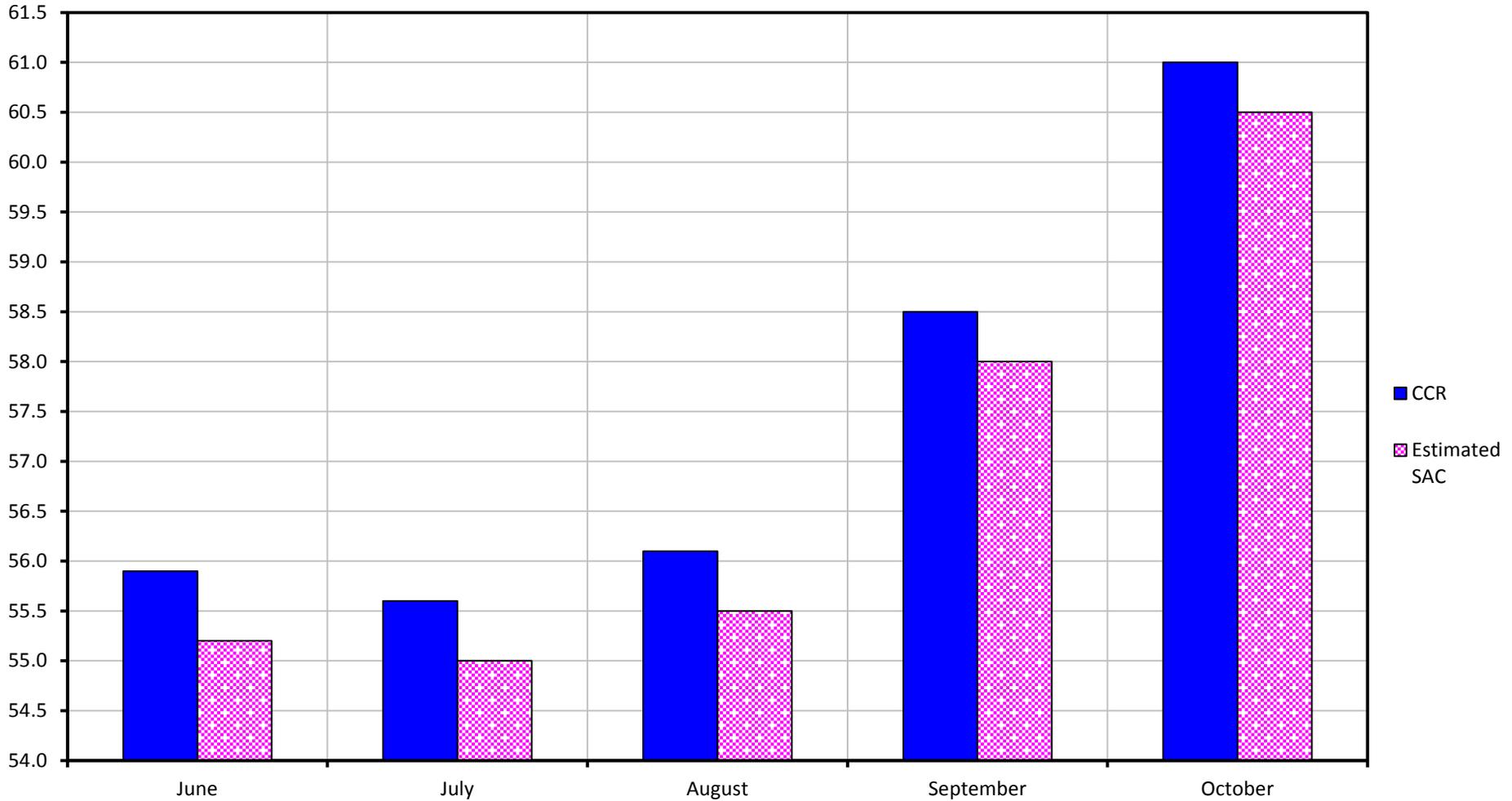


*\*June Data from 11th to 30th*

## 2015 Monthly Ave Water Temp at CCR and SAC (°F)



## 2014 Monthly Ave Water Temp at CCR and Estimated Temp at SAC (°F)



End

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9/4/2015

Temperature and Release Summary for Shasta and Trinity - August 2015

(Updated twice a week November through April)

Day	Sacramento River Water Temperatures in Degrees F Collected from CDEC (California Data Exchange Center) except for TCD, SPP and Control Point														Mean Daily Release in CFS			Mean Daily Air Temp Degrees F			
	TCD Wt. Avg.	SHD minus TCD (Diff)	Shd	SPP Wt. Avg	Kwk	Bsf	Jlf	Bnd	Rdb	Lws	Control Point 4/1 to 8/31 Ccr	Igo	Sac	Dgc	Shasta Generation El 815	Spring Crk Powerplant Release	Keswick Total Release	RDD	BSF	RDB	LWS
Jul	53.9		52.0	57.2	55.4	59.0	60.9	61.8	63.8	54.7	57.1	58.9	56.5	61.0	5,648	1,153	7,007	85.5	79.9	79.8	74.0
Aug																					
1	53.4	(1.8)	51.6	58.6	54.8	58.5	60.4	61.2	63.0	54.5	56.8	58.6	56.1	61.1	5,313	1,330	6,824	88.0	81.8	79.6	78.8
2	53.8	(2.0)	51.8	58.6	54.8	58.3	59.8	60.8	63.1	53.7	56.0	57.8	55.5	60.1	5,472	1,330	6,828	84.5	79.7	77.8	74.4
3	52.6	(1.2)	51.4	58.7	54.5	58.0	59.7	60.4	62.0	54.2	56.3	58.6	55.8	59.4	5,693	1,358	6,837	84.0	78.2	77.3	73.1
4	53.4	(1.2)	52.2	58.7	54.8	58.0	59.3	60.1	61.9	53.4	56.0	57.8	55.6	59.6	5,187	1,565	6,835	78.5	71.5	71.0	70.6
5	55.0	(1.5)	53.5	58.8	54.5	57.5	58.8	59.5	61.2	53.2	55.7	57.8	55.3	57.6	5,313	1,562	6,836	78.0	73.8	73.5	68.3
6	54.7	(1.7)	53.0	58.8	55.3	57.6	58.9	59.5	61.1	53.5	56.2	58.1	55.9	57.5	5,409	1,543	6,836	82.5	76.3	76.7	69.8
7	53.9	(1.7)	52.2	58.8	56.0	58.4	60.3	60.8	62.1	53.4	57.4	58.5	#	58.7	5,397	1,516	6,834	84.5	79.2	80.5	72.1
8	53.9	(2.0)	51.9	58.8	55.8	58.9	60.9	61.6	63.3	53.0	57.4	58.2	#	57.2	5,423	1,545	6,864	81.0	74.8	75.1	68.1
9	53.2	(1.7)	51.5	58.8	55.6	58.7	60.5	61.3	63.3	52.8	57.2	58.2	#	56.6	5,333	1,279	6,858	81.5	76.2	77.1	66.0
10	52.4	(1.3)	51.1	58.8	55.3	58.7	60.2	61.0	62.8	52.5	56.8	57.8	#	56.3	5,031	1,350	6,805	80.5	75.2	75.7	66.6
11	53.4	(1.9)	51.5	58.8	54.4	58.4	59.9	60.7	62.6	52.9	56.2	58.2	55.4	57.0	5,347	1,107	6,781	80.0	75.9	74.6	69.7
12	53.5	(1.8)	51.7	58.8	54.0	57.7	59.0	59.8	62.0	53.0	55.6	58.2	55.0	57.9	5,104	1,175	6,676	77.5	72.8	73.4	68.7
13	53.4	(1.4)	52.0	58.8	54.5	57.5	59.1	59.8	61.6	53.2	56.1	58.1	55.6	58.6	5,350	1,004	6,678	78.0	73.6	74.8	68.8
14	54.1	(1.2)	52.9	58.7	54.6	57.9	59.3	60.1	61.8	53.1	55.9	57.7	55.5	58.5	6,369	1,365	6,598	76.5	74.3	73.9	66.1
15	54.0	(1.3)	52.7	58.8	55.0	57.7	59.2	59.8	61.5	53.3	56.4	58.4	56.0	57.9	5,953	1,268	6,900	88.0	76.5	79.1	68.1
16	53.5	(1.4)	52.1	58.8	55.4	58.2	59.9	60.4	61.9	53.1	57.0	58.6	56.5	58.8	5,259	1,226	6,895	84.5	77.1	78.5	72.2
17	54.2	(1.5)	52.7	58.7	55.6	58.5	60.2	60.8	62.5	52.5	57.1	58.4	56.6	55.6	5,388	1,353	6,923	84.5	78.0	80.5	73.0
18	53.7	(1.8)	52.1	58.7	55.5	58.5	60.1	60.9	62.7	52.3	57.0	58.3	56.4	54.2	4,632	1,514	6,919	86.0	78.6	78.9	73.2
19	54.8	(2.1)	52.7	58.7	55.7	58.5	60.0	60.7	62.4	51.9	57.0	58.0	56.4	53.7	5,368	1,247	6,906	81.5	75.4	74.6	69.6
20	54.4	(1.7)	52.7	58.7	55.6	58.4	59.5	60.2	61.9	52.2	56.9	58.2	56.3	54.5	5,149	1,171	6,922	80.0	74.2	73.2	70.5
21	54.7	(1.7)	53.0	58.7	55.8	58.6	59.9	60.5	61.8	52.3	57.3	58.5	56.7	56.5	5,635	1,285	6,897	80.0	74.2	74.4	70.6
22	55.0	(1.8)	53.2	58.7	55.8	58.9	60.4	61.1	62.7	52.2	57.5	58.6	56.9	55.6	5,648	1,237	6,898	81.5	75.9	75.3	73.9
23	56.6	(3.0)	53.6	58.6	56.3	59.1	60.6	61.2	62.9	52.4	57.8	58.4	57.2	55.5	4,695	1,884	6,898	79.5	74.2	74.2	72.3
24	54.2	(1.5)	52.7	58.7	57.1	59.4	61.0	61.6	63.1	52.9	58.5	58.6	58.0	55.9	5,993	1,441	6,870	81.0	75.1	75.1	73.0
25	53.6	(1.4)	52.2	58.7	56.6	59.8	61.3	62.0	63.5	53.1	58.4	58.6	57.7	56.0	5,381	1,375	6,905	80.5	75.1	76.4	71.8
26	53.8	(1.5)	52.3	58.7	56.0	59.6	60.9	61.5	63.2	53.3	57.8	58.5	57.1	56.0	5,276	1,506	6,899	80.0	74.5	76.0	71.0
27	53.6	(1.5)	52.1	58.7	55.7	59.9	60.3	61.2	63.0	53.3	57.2	58.6	56.6	56.1	4,655	1,422	6,903	82.5	77.0	78.3	71.5
28	54.1	(1.7)	52.4	58.7	55.6	58.9	60.1	61.0	62.7	53.2	57.2	58.7	56.5	55.6	5,445	1,426	6,914	85.0	80.0	80.1	73.3
29	53.8	(1.3)	52.5	58.8	55.4	59.6	60.9	61.8	63.2	53.3	57.3	59.4	56.4	56.5	5,494	1,456	6,906	78.0	79.1	77.0	70.3
30	53.9	(1.3)	52.6	58.8	55.7	58.7	59.8	60.7	62.6	53.5	57.2	59.0	56.6	55.7	4,918	1,432	6,908	73.5	71.6	71.5	63.5
31	52.9	(0.9)	52.0	58.9	55.5	58.8	59.8	60.5	62.0	53.7	57.1	59.6	56.5	56.1	5,343	1,318	6,910	80.5	73.0	75.0	66.8
Avg Tot cfs Tot af	53.9		52.3	58.7	55.4	58.6	60.0	60.7	62.4	53.1	56.9	58.4	56.3	57.0	5,354 165,973 329,207	1,374 42,590 84,477	6,854 212,463 421,420	81.3	75.9	76.1	70.5

? = Average includes 1-9 estimated hourly readings  
# = Station out of service

! = No Average (10-17 hours missing)  
ND = No hourly readings or incorrect

& = No Average (18 to 23 hours missing)  
% = Data will be down loaded from site at later date by NCAO staff.

When available:  
^ = Redding Air Temp Record High  
\* = Redding Air Temp Record Low

Control Point: Clear Creek 4/1/2015 to 4/17/2015 at 56.0 degrees; 4/18/2015 to 5/14/2015 at 58.0 degrees; 5/15/2015 to 6/4/2015 56.0; 6/5/2015 to 8/31/2015 58.0 degrees.

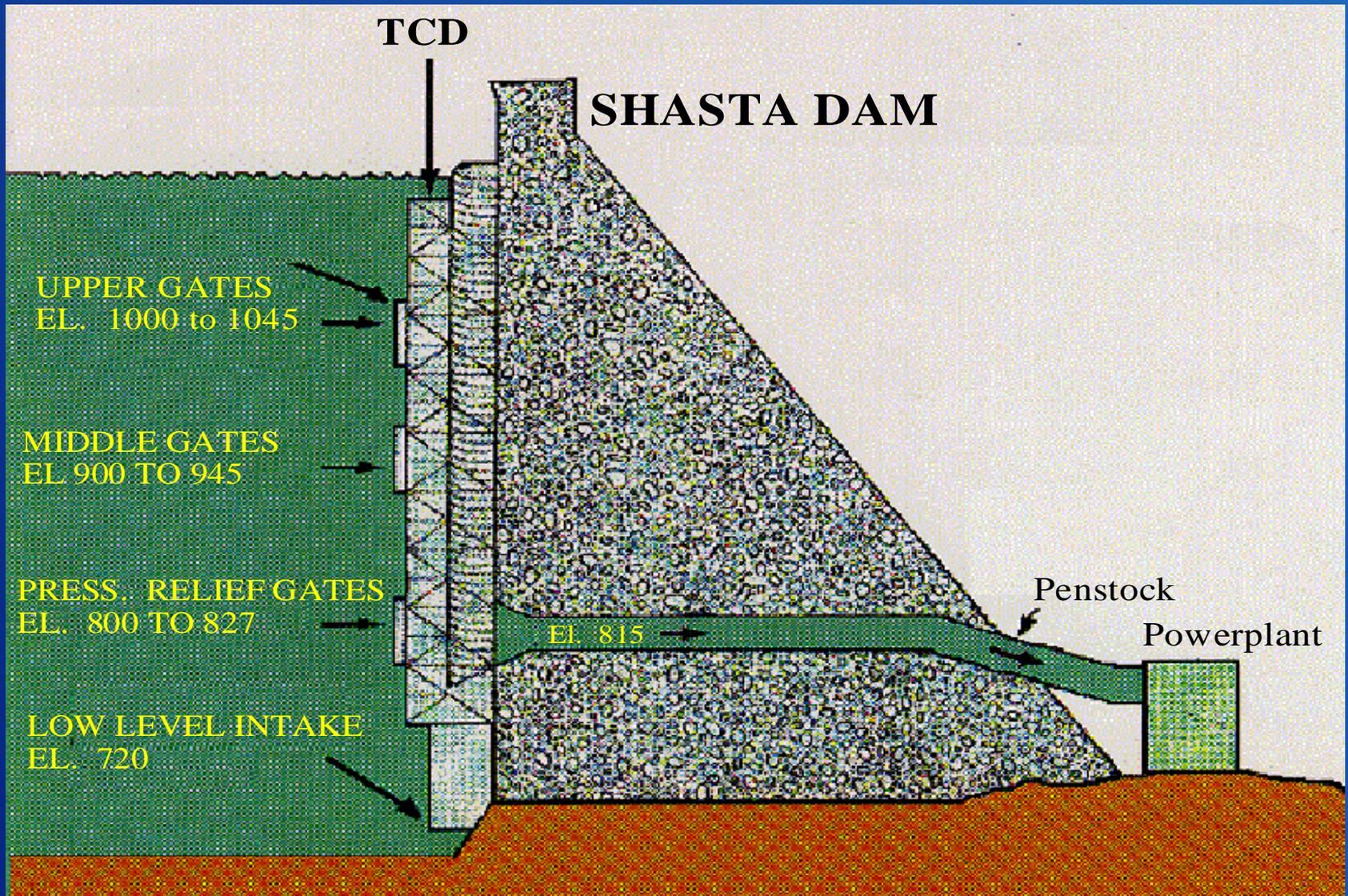


# Shasta Dam Temperature Control Device



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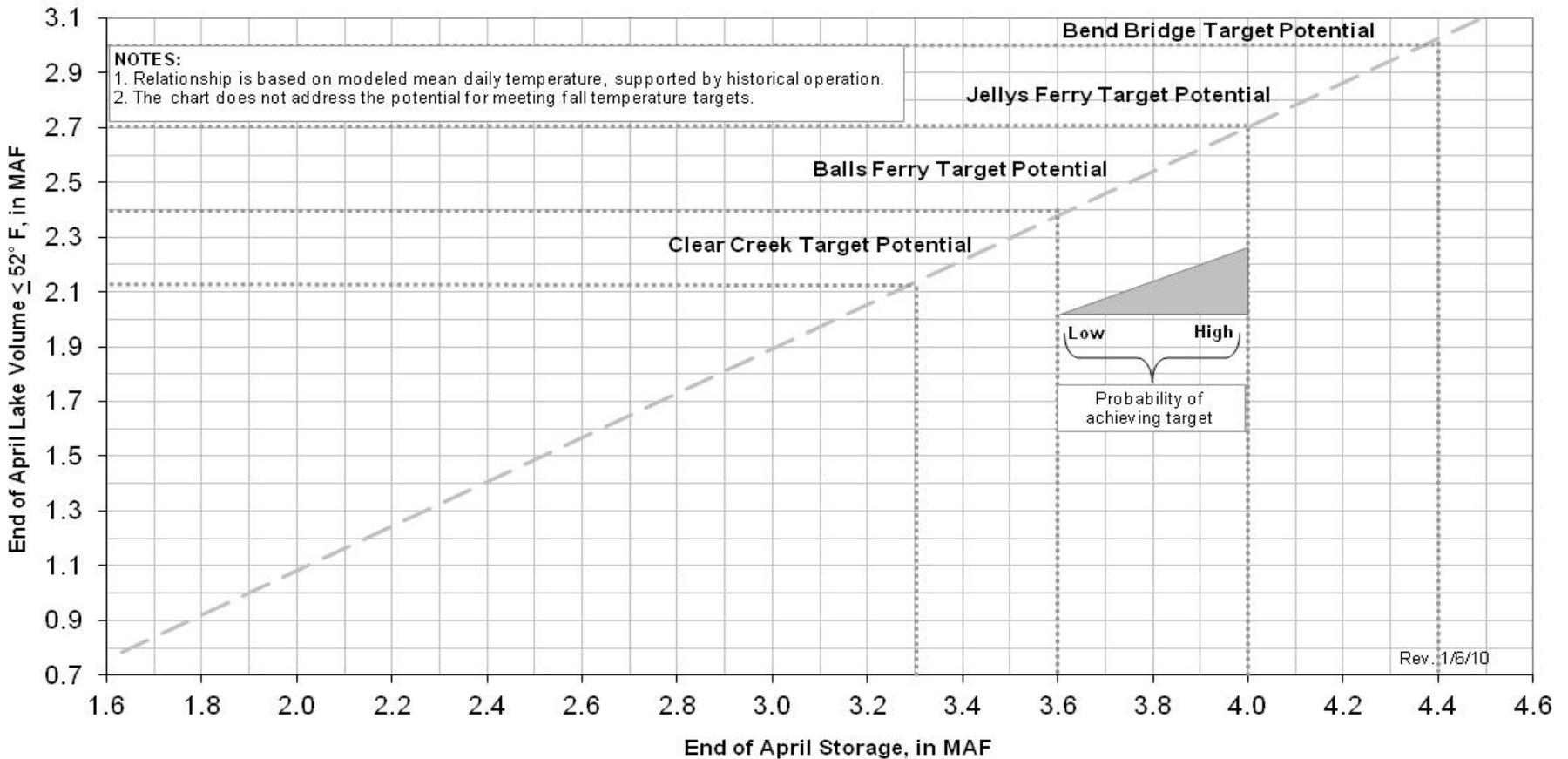
# Shasta Dam TCD Configuration



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# General “Rule-of-Thumb” Relationship

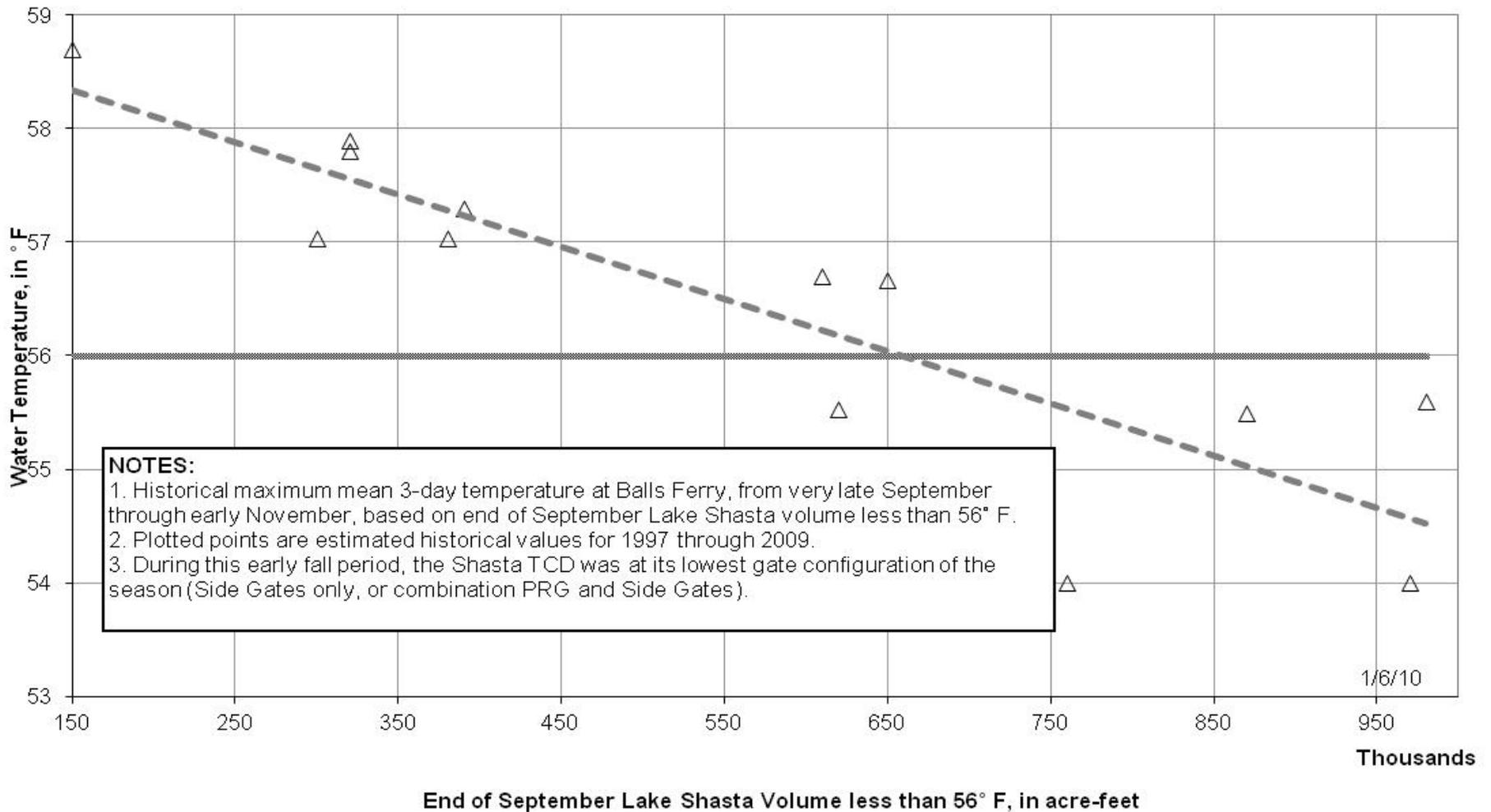
**Lake Shasta End of April Storage  
Potential for Meeting Compliance Point Target of 56° F (Apr-Sep)**



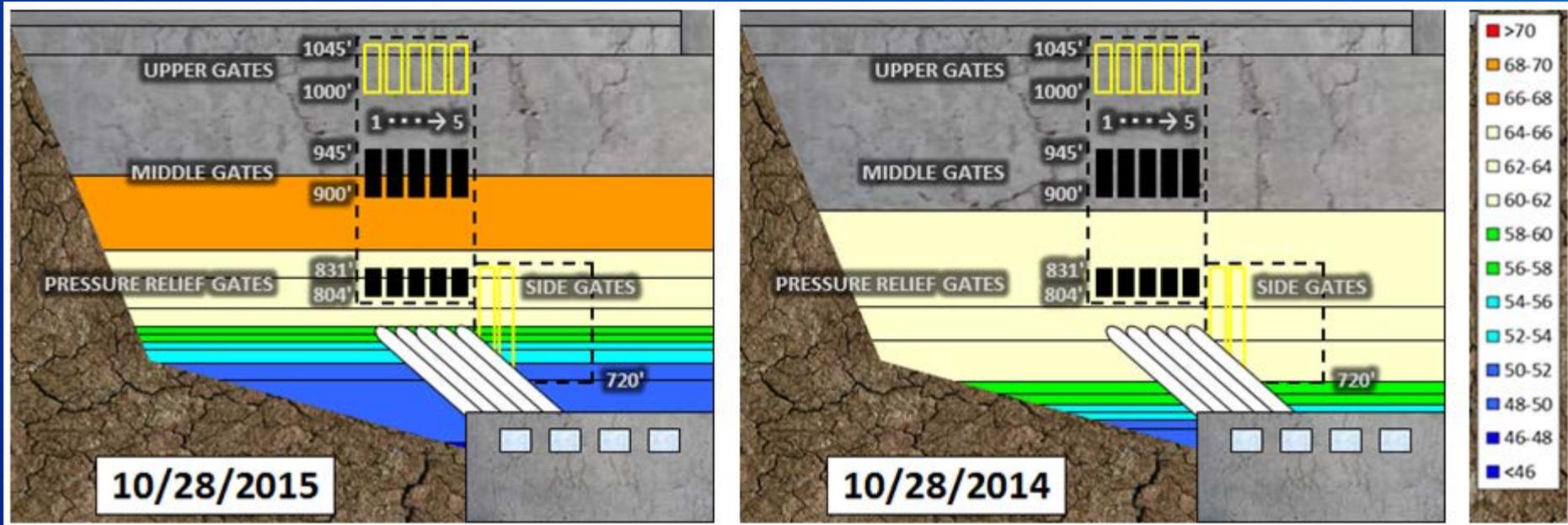
## Model Performance During Fall Months

- Based on past analyses, the temperature model does not perform well from late September through fall. One factor is that modeled release temperatures are cooler than has historically been achieved when all release is through the side gates, especially when there's a relatively large temperature gradient between the pressure relief gates (PRG) and the side gates.
- Based on historical records, the end-of-September (EOS) volume below 56°F is a reasonable indicator of fall water temperature at Balls Ferry.
- For river temperatures not to exceed 56°F downstream to Balls Ferry, the EOS lake volume less than 56°F should be greater than about 650 TAF, see figure on next slide.

## Sacramento River - Lake Shasta Early Fall Water Temperature at Balls Ferry

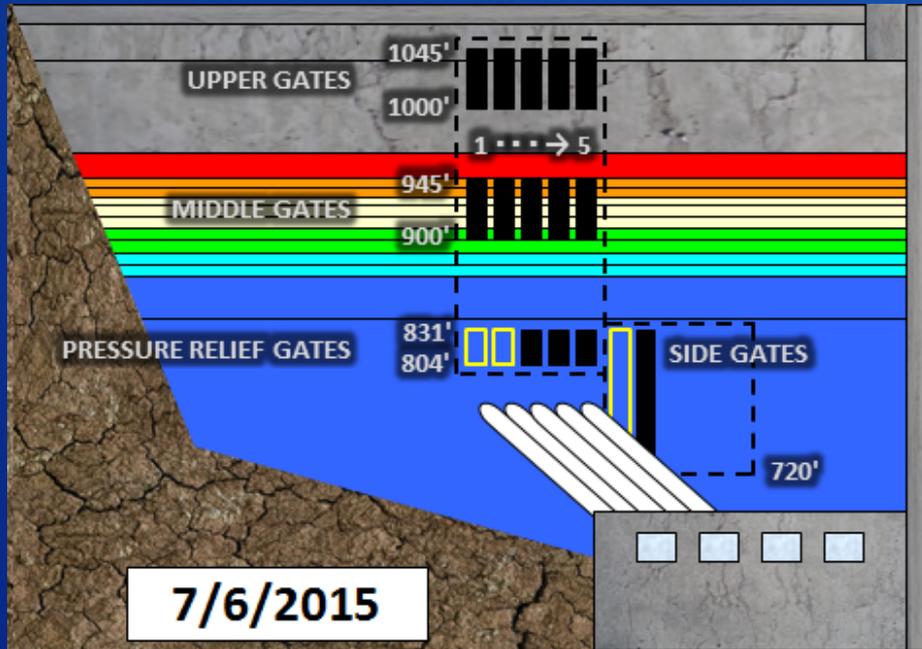


# Latest Shasta Profile

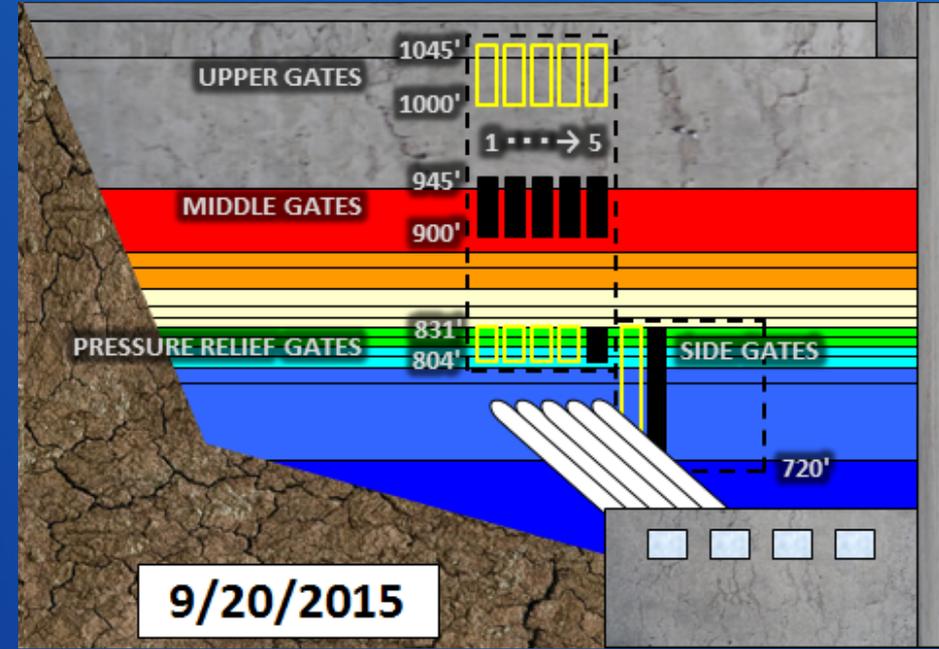


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# First Side Gate Opened (Per Model Run)



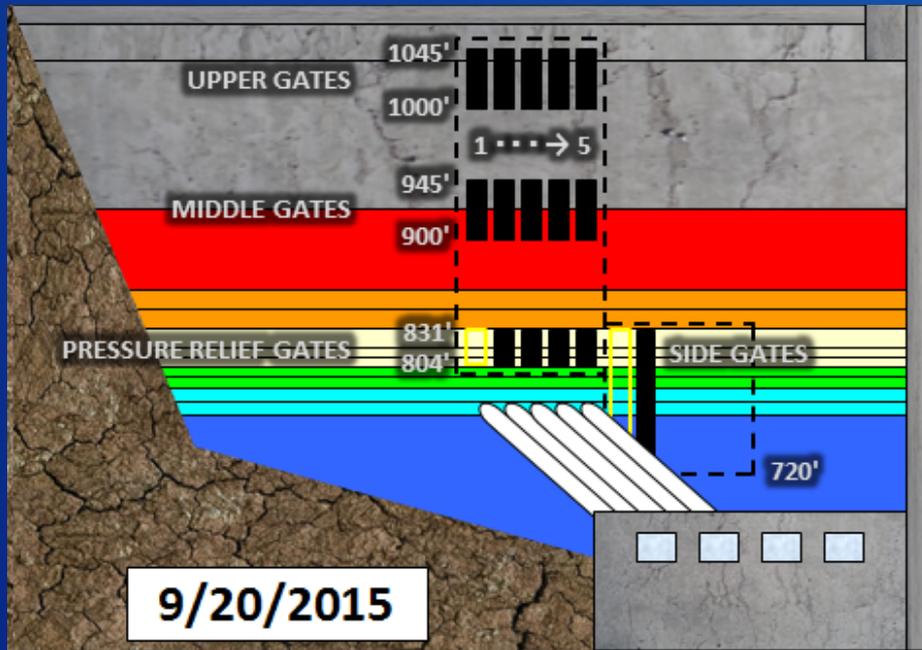
June 16<sup>th</sup> 10% model run results



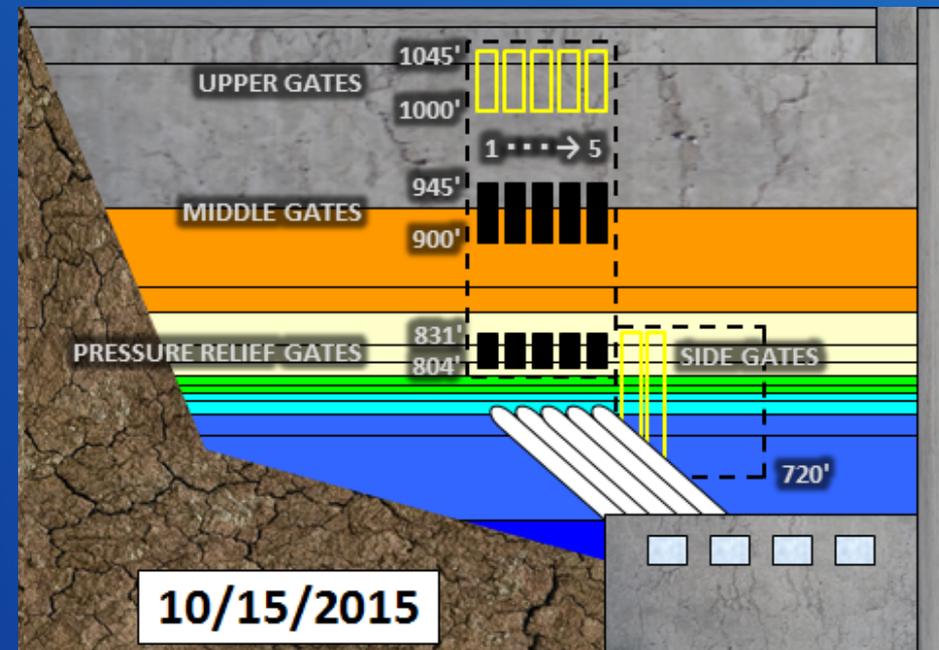
Actual Operations

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# Primary Reliance of Side Gate (Per Model Run)



September 1<sup>st</sup> 10% model run results



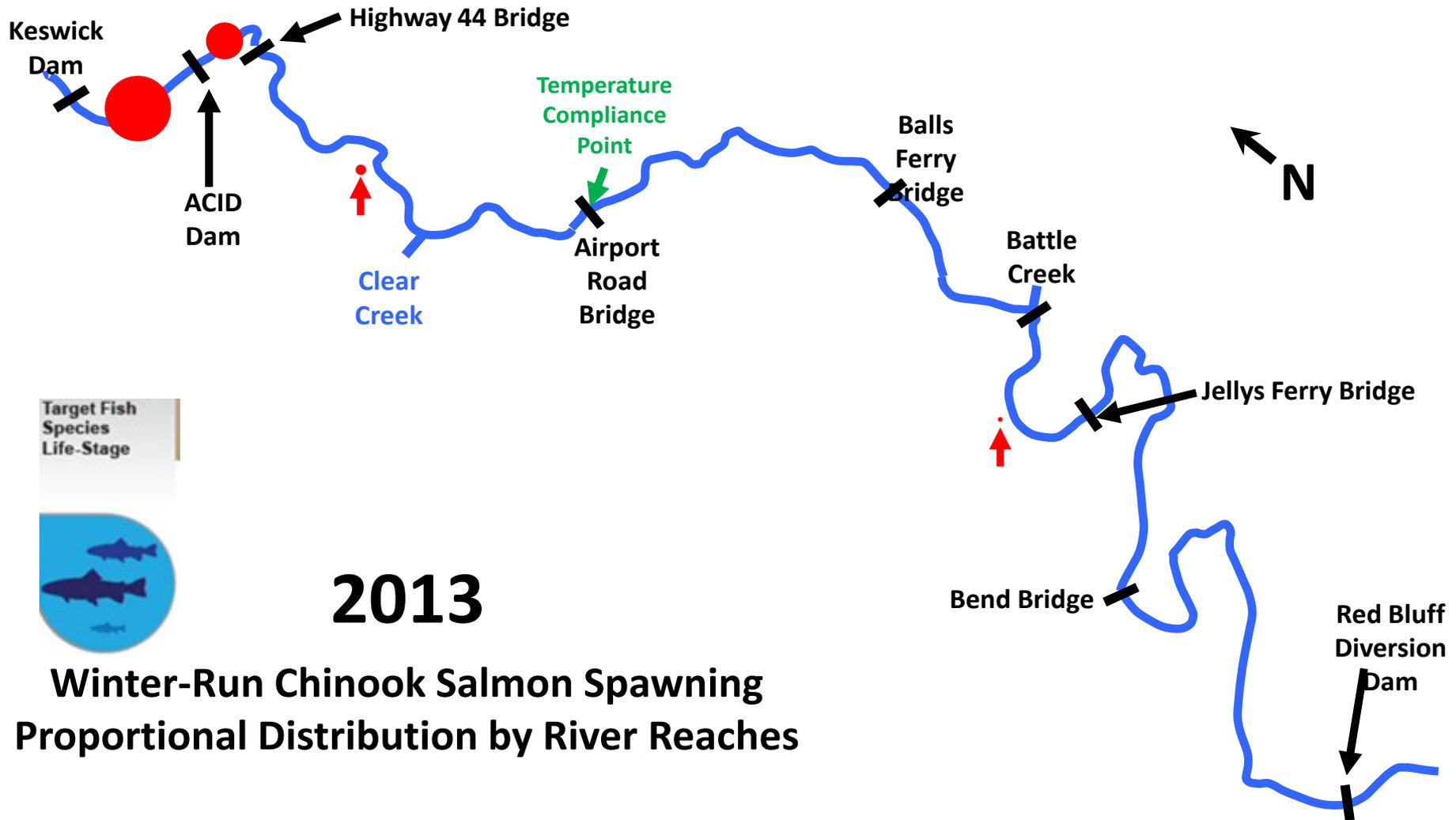
Actual Operations

# Weather Forecasting and Predictions

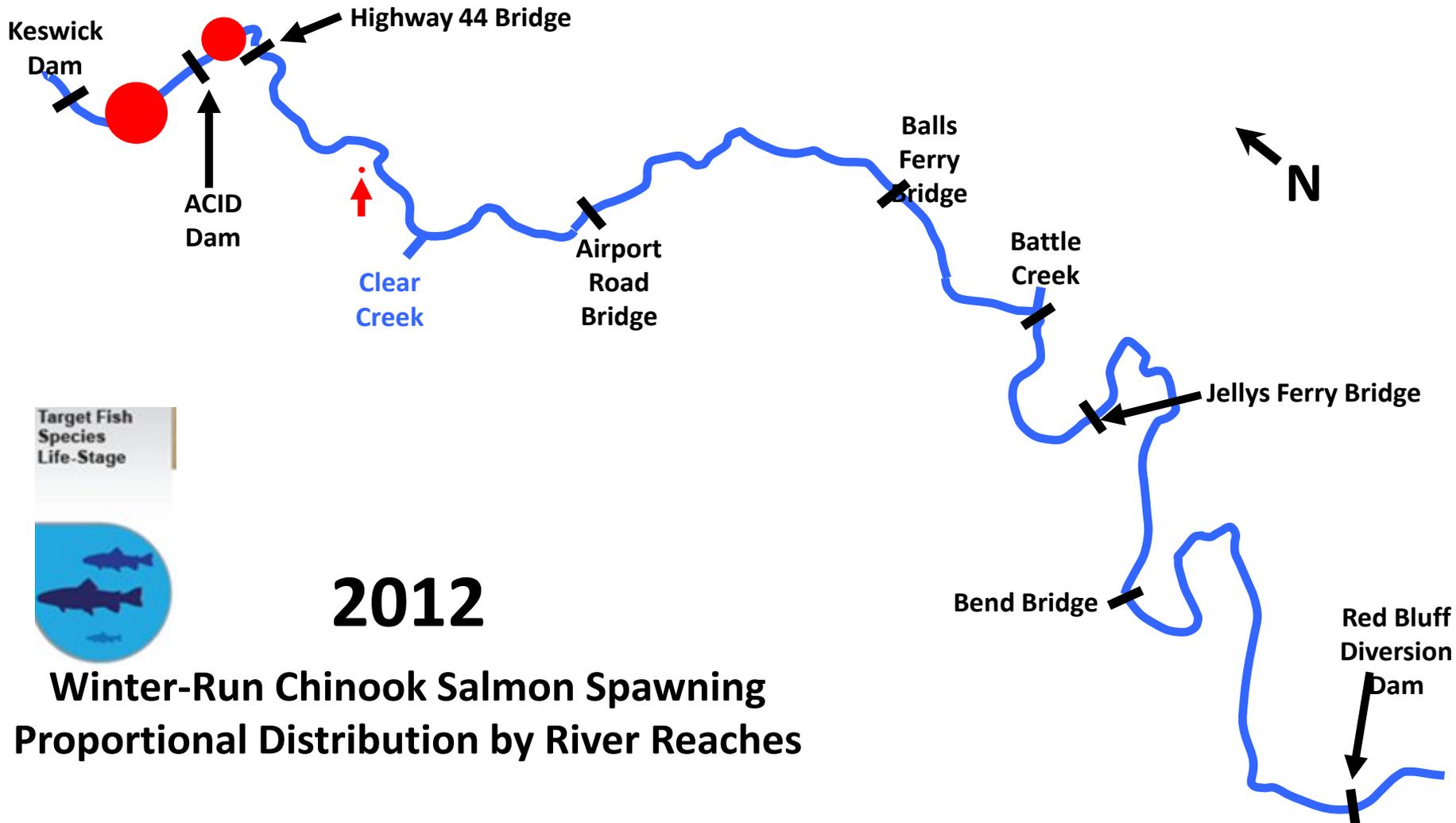


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# Real Time Winter Run Monitoring



# Real Time Winter Run Monitoring



**2012**  
**Winter-Run Chinook Salmon Spawning  
Proportional Distribution by River Reaches**