Annual Report of Activities

October 1, 2014 to September 30, 2015

Folsom Dam – Upstream reveals the Temperature Shutters infrastructure exposed at dam. August 29, 2015: Folsom Lake storage volume 199,000 acre-feet at an elevation of 367 feet (approximately 20% capacity).

Photo: Jerry Grinstead

American River Group (ARG)

September 2015

Acronyms and Abbreviations

ARG	American River Group
BiOp	Biological Opinion
cfs	Cubic Feet Per Second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CDFW	California Department of Fish & Wildlife
FMS	Flow Management Standard
LAR	Lower American River
MRR	Minimum Required Release
NMFS	National Marine Fisheries Service
Reclamation	U.S. Bureau of Reclamation
RM	River Mile
RPA	Reasonable and Prudent Alternative
RTDOT	Real-Time Drought Operations Management Team
SWP	State Water Project
SWRCB	State Water Resources Control Board
TCD	Temperature Control Device
USFWS	U.S. Fish & Wildlife Service

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Chapter 1 – Background

1.1 American River Geographic Orientation

The American River is the second largest tributary to the Sacramento River located in California's Central Valley. The North, Middle, and South forks of the American River originate in the Sierra Nevada range and then flow into Folsom Reservoir, approximately 25 miles east of the City of Sacramento, California. Folsom Dam and Reservoir as well as Nimbus Dam and Lake Natoma are features of the Central Valley Project (CVP) operated by the U.S. Bureau of Reclamation (Reclamation). The lower American River (LAR) reach begins at Nimbus Dam, approximately river mile (RM) 23, and continues downstream until its confluence with the Sacramento River. Figure 1 illustrates the LAR and surrounding features.

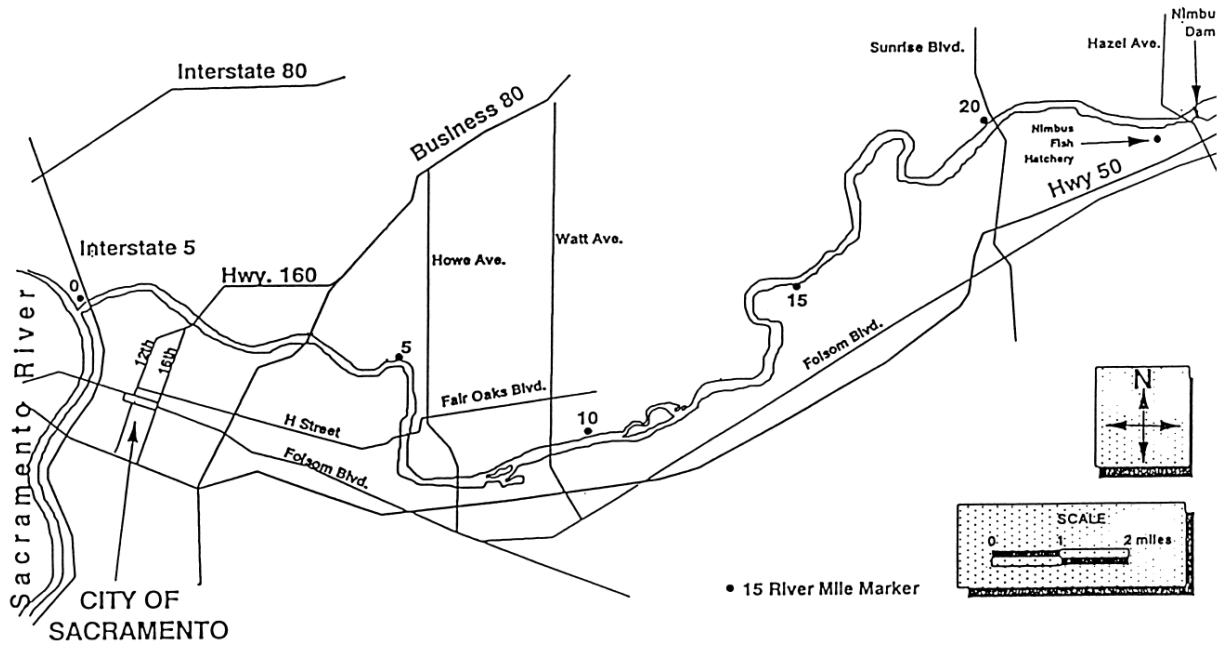

Figure 1. The lower American River between Nimbus Dam and the Sacramento River.

1.2 Lower American River Historical Background

The LAR is a significant resource of considerable interest and provides water supply to urban and agricultural uses, flood control, fish and wildlife protection, recreational opportunities, hydroelectric power generation, and protects conditions in the Sacramento-San Joaquin Delta. The regulating facilities of the Folsom/Nimbus Dam complex include Folsom Dam, Reservoir and Powerplant, Nimbus Dam and Powerplant, and Lake Natoma. Releases from Folsom Dam are re-regulated approximately seven miles downstream by Nimbus Dam. Nimbus Dam creates Lake Natoma, which serves as a forebay for the diversions to the Folsom South Canal. Additional facilities include the Nimbus Fish Hatchery, at Nimbus Dam, owned by Reclamation and operated by the California Department of Fish and Wildlife (CDFW).

Reclamation operates Folsom/Nimbus Dam under a state water right permit and fish protection requirements that were adopted in 1958 as the State Water Resources Control Board (SWRCB) Decision 893 (D-893). This decision allows flows at the mouth of the American River to fall as low as 250 cubic feet per second (cfs) from January through mid-September, with a minimum of 500 cfs required between mid-September through December 31. However, many recognize D-893 flows do not provide comprehensive habitat protection. Since 1958, additional SWRCB Decisions, Congressional Acts (i.e. Central Valley Project Improvement Act (CVPIA), and a Federal Biological Opinion (BiOp) Reasonable and Prudent Alternative (RPA) (NMFS 2009 BiOp, Appendix 2D and 2011 RPA amendment), have changed the regulatory landscape for the State and Federal Water Projects.

The Water Forum, comprised of local American River stakeholders, has successfully joined together water purveyors, environmentalists, agriculturalists, business leaders, along with city and county governments in Sacramento, El Dorado and Placer counties in an agreement to secure Sacramento region water supply through the year 2030. The Water Forum has promoted operational changes with coequal objectives: “to provide a reliable supply for planned development to the year 2030, and to preserve the Sacramento region’s environmental crown jewel, the lower American River”. The Water Forum, in cooperation with Reclamation, National Marine Fisheries Service (NMFS), Untied States Fish and Wildlife Service (USFWS), and CDFW developed a draft Flow Management Standard (FMS) for the LAR to potentially improve the conditions of aquatic resources in the LAR. The FMS design is to improve habitat conditions for fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) fish in the LAR by enhancing minimum flows and water temperature, establishing a formal management process, and facilitating coordinated monitoring, and evaluation and reporting (Water Forum 2006).

The FMS was included in the NMFS 2009 BiOp on the Long-Term Operations of the CVP and State Water Project (SWP) RPA (Appendix 2D and 2011 RPA amendment). The FMS flow criteria have been tracked since 2006 and implemented, per the NMFS 2009 BiOp RPA action, since 2009. Reclamation continues to work with the Water Forum, NMFS, CDFW, USFWS, and other interested parties to integrate a revised flow management standard for the LAR into CVP operations and associated water rights.

The FMS is designed to integrate temperature performance capability for management of the downstream habitat. The NMFS 2009 BiOp also adopted components of the FMS temperature management process.

Because water temperature control operations in the LAR are affected by many factors and operational tradeoffs, ideal downstream temperature targets are sometimes infeasible (particularly with multiple years of below normal or dry conditions). The factors include available cold water resources, Nimbus release schedules, annual hydrology/snow pack, Folsom power penstock shutter management flexibility, Folsom Dam Urban Water Supply Temperature Control Device (TCD) management, power generation, and Nimbus Fish Hatchery operations and maintenance. Two structural devices provide downstream temperature management: (1) the Folsom Shutters and (2) the TCD. These devices control the desired downstream temperature by selecting the elevation where the water is withdrawn from the reservoir. In addition to accessing cooler water using the shutter elevations, a blending operation can also be employed where shutters at differing elevations are mixed or blended for temperature management. Lastly, when temperature operations exhaust the reservoir's coldwater pool past the lowest shutter locations prior to the fall, Reclamation has the ability to bypass the Folsom Shutters (power generation) to release the coolest water from the river outlets, the lowest elevation outfall in Folsom Dam, to maintain targeted temperatures in the LAR.

Reclamation established a working group to coordinate fishery and operational requirements for the LAR, known as the American River Group (ARG), in 1996. Reclamation is the lead coordinator of the ARG, bringing together those who have either a legislated or resources-specific interest in the operation of Folsom Dam and Reservoir, and the LAR. Agencies with trust responsibilities for the water resources in the LAR and the surrounding areas participate. Members of the public and other agencies may attend ARG meetings and are encouraged to comment on matters under consideration by the ARG. The ARG convenes monthly or more frequently, if needed, with the purpose of providing fishery updates and reports to help inform management decisions regarding temperatures and flows necessary to sustain fish resources in the LAR.

Chapter 2 –Reasonable and Prudent Alternative (RPA) Actions (NMFS 2009 BiOp)

2.1 Summary of RPA Actions

On June 4, 2009, NMFS issued its BiOp and Conference Opinion on the Long-Term Operations of the CVP and SWP that included RPA actions for the LAR. The ARG was included amongst the four Fisheries and Operations Technical Teams whose function is to make recommendations for adjusting operations to meet contractual obligations for water delivery and to minimize adverse effects on listed anadromous fish species (see Section 11.2.1.1, NMFS 2009 BiOp).

There are several RPA actions that discuss minimal flow requirements and temperature objectives for the LAR: Action II.1.; "Lower American River Flow Management", Action II.2; "Lower American River Temperature Management", and Action II.4; “Minimize Flow Fluctuation Effects” (NMFS 2009 BiOp, Appendix 2D, and 2011 RPA amendment). The objectives of these RPA actions are to provide minimum flows for all stages of steelhead and to maintain suitable temperatures to support over-summer rearing of juvenile steelhead. A Temperature Management Plan is prepared for NMFS' consideration in May of each year that takes into consideration actions under Reclamation's authority using iterative modeling techniques (i.e. The iterative Coldwater Pool Management model-see NMFS 2009 BiOp, Appendix 2D). Since 2009 Reclamation and NMFS continue to work together to address all of the elements of the RPA actions.

Chapter 3 – Summary of ARG Discussions

The following agenda items were discussed at monthly ARG meetings from October 2014 through September 2015. Meeting notes and supplemental ARG documents were made available.

3.1 Monthly Discussion Topics

- **Lower American River Fisheries Monitoring**
  - The status of current fisheries monitoring activities provided by Reclamation, NMFS, USFWS, and CDFW, as well as planned future fisheries monitoring activities.
- **Water Operations and Water Quality**
  - Flows measured at Nimbus Dam, temperatures at Watt Avenue. See Chapter 4.
- **NMFS BiOp RPA Actions – American River Division:**
  - **RPA Action II.1 – Lower American River Flow Management**

    Goal: Implementation of flow schedule specified in the FMS, which is summarized in Appendix 2-D of the NMFS 2009 BiOp.

    Discussion: Reclamation convenes the ARG to make recommendations for management within the constraints of the FMS.
  - **RPA Action II.2 – Lower American River Temperature Management**

    Goal: Maintain suitable temperatures to support over-summer rearing of juvenile steelhead in the LAR.

    Discussion: Reclamation convenes the ARG to make recommendations regarding cold water management alternatives to improve water temperature conditions for fish, including potential power bypasses.
  - **RPA Action II.4 – Minimize Flow Fluctuation Effects**

    Goal: Reduce stranding and isolation of juvenile steelhead through ramping protocols.

    Discussion: Reclamation convenes the ARG to make recommendations regarding ramping protocols and monitoring activities to effectively adjust releases from Nimbus to reduce the risk of stranding and isolation of steelhead.

3.2 Other Discussion Topics

- **Central Valley Project Improvement Act**
  - **LAR Gravel Augmentation Program**

    Restore and replenish spawning and rearing habitat that was lost due to the construction and operation of the CVP. Spawning and rearing habitat restoration projects on the LAR are part of a continuing program under the CVPIA. The 2014 Project was constructed

just downstream of the Nimbus Dam, in Nimbus Basin at approximately RM 23. The project included the addition of 12,000 tons of spawning gravel in the main channel and the creation of a side-channel approximately 350 yards long with the incorporation of woody material. The project could create approximately 3.3 acres (combined) of spawning and rearing habitat that was lost due to the construction of the CVP dams. 2015 gravel activities were postponed due to permitting issues and are anticipated next year.

- **LAR fall-run Chinook Carcass Survey**

  Estimate the escapement of fall-run Chinook salmon in a 13.1-mile section of the LAR from Nimbus Hatchery weir downstream to the Watt Avenue Bridge. The objectives of the surveys are to: 1) estimate the population size of returning Chinook salmon spawning in a 13.1-mile section of the LAR; 2) determine the general age and sex of returning Chinook salmon; 3) determine pre-spawning mortality; and 4) determine the ratio of returning hatchery-reared, coded-wire tagged salmon. The 2014/2015 preliminary escapement estimate of fall-run Chinook salmon in a 13.1-mile section of the LAR from Nimbus Hatchery weir downstream to the Watt Avenue Bridge is roughly 12,000, less than half of the previous year's return. The survey began in mid-October and ran for thirteen weeks. The preliminary results indicated a late start to the run with the peak occurring one to two weeks later than the previous year. The surveyors did not see an unusual occurrence of pre-spawning mortality.

Chapter 4 – Water Operations Summary

General Water Year Conditions and Operations

Water year 2015 yielded little hydrologic relief to the on-going drought. This year, the fourth year of consecutive dry year conditions, provided just 22% of the April through July full-natural-flow statewide average (DWR 2015). Extremely low precipitation volumes, snow-pack, and reservoir storages contributed to very challenging operations of the CVP and SWP water storage and delivery systems. The regulatory requirements and system constraints offer some operational flexibility due to drier hydrology, but are insufficient to restore system expectations to "normal" conditions. In mid-December Reclamation, DWR, NMFS, USFWS, and CDFW released an "Interagency 2015 Drought Strategy for the Central Valley Project and State Water Project", and again in mid-January a multi-agency team released a guiding document called "Central Valley Project and State Water Project Drought Contingency Plan: January 15, 2015 through September 30, 2015" providing multi-agency objectives and purposes for state-wide project operations. Operational updates evolved throughout the year and were submitted to the California State Water Resources Control Board. This year produced similar to conditions last year where prolonged drought resulted in the dependency of previously stored water supplies and reduced carryover storage, degraded water quality, reduced deliveries, and lower flow rates/reduced stage.

Hydrologic Conditions – American River

Watershed runoff in California is typically driven by winter precipitation and spring snow-melt runoff and quantified as a late spring through summer inflow volume (April through July volume, in addition to a water year total volume). The American River watershed spring/summer forecasted inflow volume is fundamental in operational planning and is a product updated routinely from the Department of Water Resources (DWR) and the National Weather Service-California Nevada River Forecast Center (CNRFC), where uncertainty is represented by percent runoff exceedences). The initial April – July 90% (conservative volume) unimpaired runoff exceedence forecast volume (February) was estimated at 190 TAF, just 15% of the average (690 TAF was projected for the water year, much lower than the average water year volume of 2,683 TAF.). The actual full natural flow volume April –July in 2015, was 185 TAF (final water year information is not yet available). The following table provides data and characteristics of water year 2015 (Table 1). Because operational planning is significantly influenced by future forecasts, these uncertainties and eventually modified decisions are translated into the performance and efficiency of the system-wide operation.

Table 1. 2015 Water Year Northern Sierra precipitation, American River Basin snowpack, and Sacramento Valley Index statistics by month.

Water year 2015 Month	Northern Sierra 8-Station Precipitation (Cumulative water year in inches through month)	Northern Sierra 8-Station percentage of historic monthly average (for month)	American River Basin Snowpack (percent of April 1 average)	Sacramento Valley Index (40-30-30 Index 50% Exceedence)
November	7.58	62%	NA	NA
December	22.79	181%	NA	5.6 (Dry)
January	23.07	3%	16%	6.7 (Below Normal)
February	30.64	95%	8%	5.1 (Critical)
March	31.65	14%	5%	4.7 (Critical)
April	34.03	62%	1%	4.1 (Critical)
May	35.19	57%	0%	4.0 (Critical)

(DWR 2015)

Operations – Lower American River

Operational decisions on the LAR are influenced by local and CVP and SWP system-wide multi-purpose objectives including those that are planned and uncertain. Many factors contribute to operational actions including, but not limited to: flood protection, forecasted inflows, facility maintenance schedules, physical/mechanical facility limitations, upstream operations, minimum in-stream flow criteria, downstream Delta regulatory requirements, Delta exports, power generation, recreation, fish hatchery accommodations, temperature management capabilities, and others. In addition, uncertain or unplanned events can also influence real-time operation decisions (e.g. additional flow reduction for debris removal prior to fish weir and picket installation for the Nimbus Fish Hatchery in 2013). Planned operational targets are regularly updated late winter through early summer (depending on hydrologic conditions) on Reclamation's website (http://www.usbr.gov/mp/cvo/) (Reclamation 2015).

Key decisions that influenced 2015 LAR operations:

- Minimum flow rate/FMS: Codified flow criteria were developed with consideration for low storage/low precipitation conditions that address the objectives to meet future in-stream temperature objectives and water supply needs. This year hydrologic and storage conditions for both an "Off-Ramp" and "Conference Year" were satisfied. Although flow reductions for these conditions were delayed approximately two weeks due to fishery concerns, March flows were

reduced to 500 cfs in concert with temperature management operations to conserve storage and protect incubating steelhead redds. As a consequence, storage conditions were insufficient to install the top row of temperature shutters and increased the likelihood of degraded temperature performance. In addition, flows are also expected to drop below 800 cfs in the fall for storage conservation due to very low storage conditions.

- Sacramento River fishery protection priority: Due to critical conditions in the Sacramento River, NMFS prioritized Winter Run Chinook salmon and requested Shasta Lake storage conservation for temperature management purposes. This resulted in limited summer Keswick releases (7,200 cfs June through August). The tradeoff was increased American River water releases as required to meet SWRCB Delta water quality requirements. In turn, higher than anticipated releases and lower than anticipated storage conditions occurred.
- Reduced flows were closely coordinated with the City of Sacramento operational needs during plant outage/repairs.
- Storage conservation targets of 120 TAF or greater: Contingency plans are underway to provide uninterrupted municipal and industrial diversion capacity if reservoir storage conditions drop below 120 TAF (construction of a temporary floating pump barge is expected to be complete by early November).
- Reduced CVP Deliveries: The CVP reduced water allocations to the following groups:
    - South of Delta Agricultural Contractors to 0%,
    - South of Delta Municipal and Industrial Contractors to 25%, and
    - American River Municipal and Industrial Contractors to 25%.
- Reduced Delta project pumping during the summer months
- Temporary Urgency Change Petition- SWRCB permit conditions: Reclamation and DWR sought relief from multiple requirements due to record low precipitation/poor runoff conditions to protect water resources.
- Cold Water Pool (CWP): The historical conditions of the CWP volume is recorded in Table 2 for comparison.
- Temperature Management Plan: At the beginning of August (given initial conditions, 90% runoff exceedence forecast, and future assumptions) the Iterative Cold-Water Pool Management Model (iCPMM) results indicated a reasonably feasible maximum mean daily temperature target at Hazel Avenue Bridge of 71°F and Watt Avenue Bridge of 75°F. Typically the model iteratively trades-off (pre-assumed) habitat benefits between steelhead and fall-run Chinook temperature conditions. This information was conveyed to NMFS, updated monthly, and discussed with the ARG.
- Cold Water Bypass: Reclamation is tentatively planning a cold-water bypass (foregoing power generation) to release water from the deepest elevation in Folsom Reservoir to manage fall Nimbus Dam release temperatures.

Table 2. Historical Folsom Reservoir Cold Water Pool dynamics.

Historical Conditions (2001-2014)						
Year	**End of May**		**All Upper Shutters Lowered by**	**End of September**		**Watt Avenue Target (˚F)**
	Storage (TAF)	**CWP Volume < 58˚F (TAF)**		**Storage (TAF)**	**CWP Volume < 60˚F (TAF)**	
2001	696	275	30 Mar	368	30	65-71
2002	822	455	04 Mar	510	50	65-69
2003	962	640	02 Apr	658	135	65-67
2004	635	300	05 Mar	376	30	69
2005	959	705	15 Mar	652	140	65
2006	928	670	29 Mar	639	125	65
2007	787	355	21 Mar	323	30	68
2008	617	250	None Lowered	270	25	69-70
2009	933	550	12 Mar	412	60	67
2010	905	580	14 Apr	624	130	66
2011	880 (960-July)	590	28 Mar	740	180	65
2012	926	536	29 Mar	450	60	65-66
2013	734	277	15 Apr	361	50	69
2014	548	200	None Lowered	345	35	70
2015	576	256	None Lowered	174	39	75

4.1 RPA Action II.1 – Lower American River Flow Management

RPA Action II.1 is designed to provide minimum flow for all steelhead life stages, as specified by the FMS. These Minimum Release Requirements (MRR) are total releases measured at Nimbus Dam and are dependent on upstream storage and hydrologic conditions. The prescribed flows are minimums only and do not preclude Reclamation from making higher releases. Storage and flood control conditions are illustrated in Figure 2 which also includes inflow and releases October 2014 through September 2015.

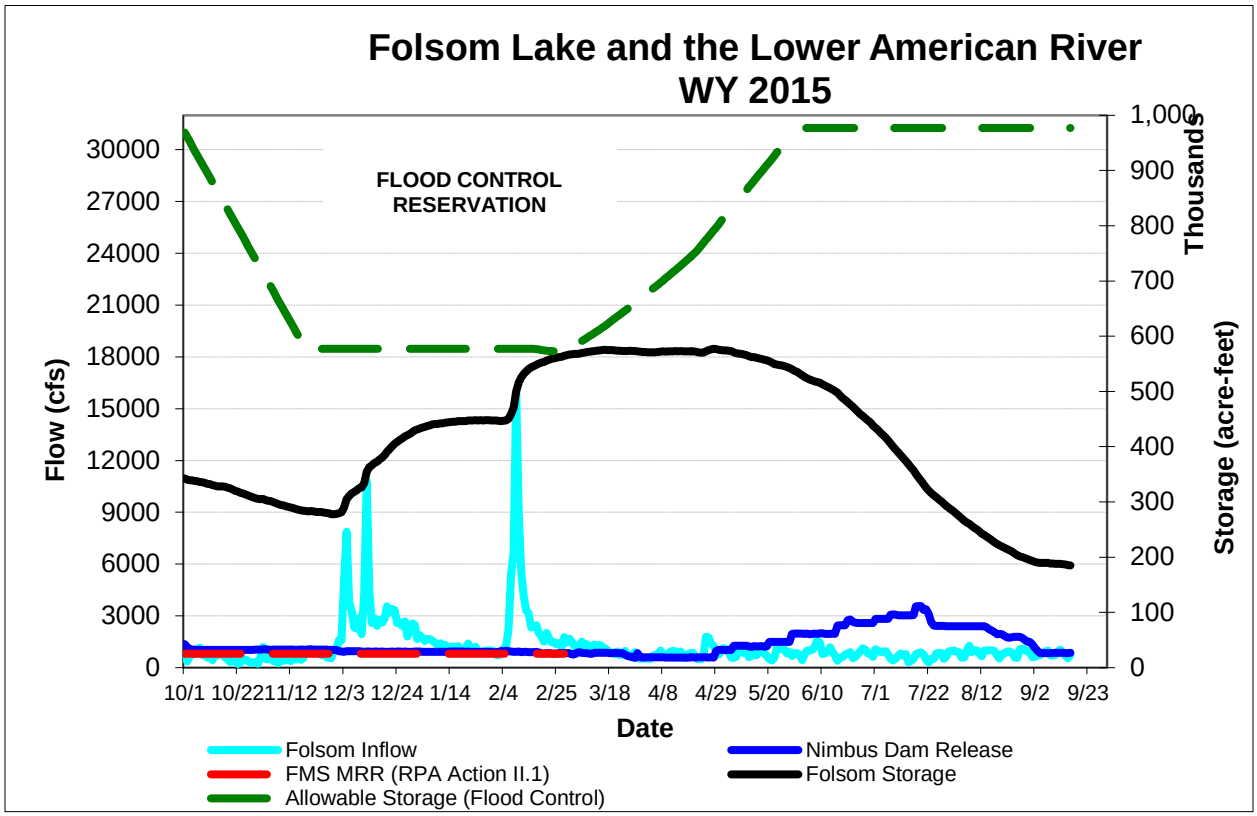

Figure 2. Summary of Folsom Reservoir Storage and Lower American River Flows[1]

The Nimbus Dam releases to the LAR and the MRR prescribed by the FMS for water year 2015 is shown on Figure 3. In addition, the primary reasons for release changes to the LAR are identified on the figure. Operational decisions were closely coordinated with agencies as a result of the extreme drought situation. Hydrologic conditions for both an "Off-Ramp" and "Conference Year" were satisfied in 2015. During the spring the FMS MRR operational decisions were outside "normal conditions" and were decided based on multi-agency input. Coordination occurred during ARG and Real-Time Drought Operations Management Team (RTDOT) meetings. RTDOT is a multi-agency team created in response to a State Water Resources Control Board Order dedicated to resolve real-time operational issues.

[1] FMS MRR (RPA Action II.1) Conference/Offramp Drought Operations are effective beginning March 2015.

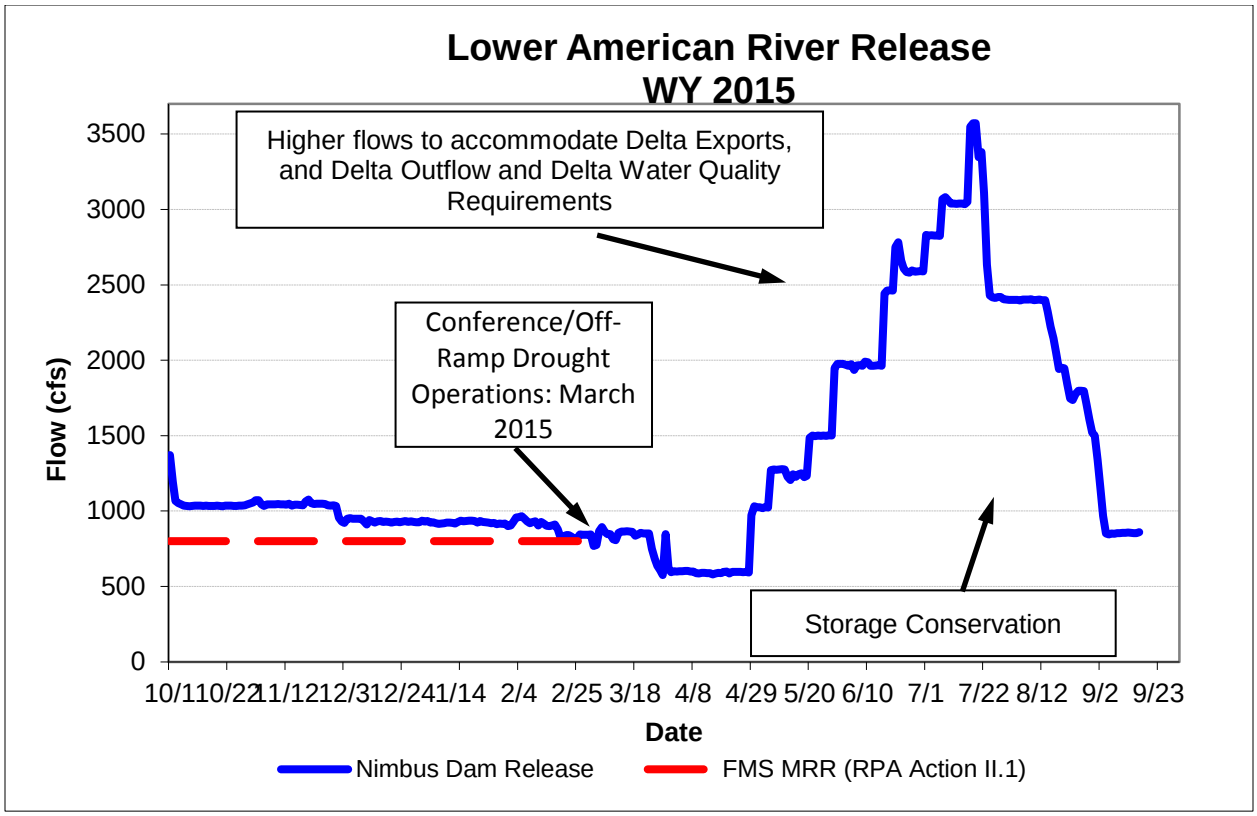

Figure 3. Summary of Lower American River Releases at Nimbus Dam

Table 3 contains a summary of operational release changes from Nimbus Dam including the purpose. Flow management adjustments were predominately for storage conservation and Delta management.

Table 3. Release Changes at Nimbus Dam

Start Date	End Date	Release	To (cfs)	Comment
10/2/2014	10/2/2014	Decrease	1,200	Storage conservation
10/3/2014	10/3/2014	Decrease	1,050	Storage conservation
12/1/2014	12/1/2014	Decrease	900	Storage conservation
2/18/2015	2/18/2015	Decrease	850	Storage conservation
2/19/2015	2/19/2015	Decrease	800	Storage conservation
3/24/2015	3/24/2015	Decrease	700	Storage conservation
3/25/2015	3/25/2015	Decrease	600	Storage conservation
3/26/2015	3/26/2015	Decrease	500	Storage conservation
3/29/2015	3/30/2015	Increase/Decrease	800 - 500	Temporary increase/decrease in flow to push cooler water downstream
4/29/2015	4/29/2015	Increase	1,000	Delta outflow requirements
5/6/2015	5/6/2015	Increase	1,250	Delta Salinity
5/20/2015	5/20/2015	Increase	1,500	Delta Salinity
5/29/2015	5/29/2015	Increase	2,000	Delta Outflow and Salinity
6/16/2015	6/16/2015	Increase	2,500	Delta Requirements
6/20/2015	6/20/2015	Increase	2,750	Delta Requirements
7/1/2015	7/1/2015	Increase	3,000	Delta Requirements
7/7/2015	7/7/2015	Increase	3,250	Delta Salinity
7/17/2015	7/24/2015	Increase/Decrease	3750-2500	Temporary increase/decrease in releases to accommodate temperature shutter modifications at Folsom Dam. Action coordinated with DWR and Feather River releases. Expect no net loss in storage as a result of this action.
8/14/2015	8/14/2015	Decrease	2,400	Storage conservation
8/15/2015	8/15/2015	Decrease	2,300	Storage conservation
8/16/2015	8/16/2015	Decrease	2,200	Storage conservation
8/17/2015	8/17/2015	Decrease	2,100	Storage conservation
8/18/2015	8/18/2015	Decrease	2,000	Storage conservation
8/21/2015	8/21/2015	Decrease	1,900	Storage conservation
8/22/2015	8/22/2015	Decrease	1,800	Storage conservation
8/28/2015	8/28/2015	Decrease	1,700	Storage conservation
8/29/2015	8/29/2015	Decrease	1,600	Storage conservation
8/30/2015	8/30/2015	Decrease	1,500	Storage conservation
9/1/2015	9/1/2015	Decrease	1,300	Storage conservation
9/2/2015	9/2/2015	Decrease	1,100	Storage conservation
9/3/2015	9/3/2015	Decrease	900	Storage conservation
9/4/2015	9/4/2015	Decrease	800	Storage conservation

4.2 Action II.2 - Lower American River Temperature Management

RPA Action II.2 is designed to provide suitable temperatures to support over-summer rearing of juvenile steelhead in the LAR. Figure 4 is a summary of Reclamation's temperature operations, from October 2014 through September 2015, to target the temperature requirements at the temperature compliance point at Hazel Avenue Bridge (~RM 22.5) and Watt Avenue Bridge (~RM 9). A Temperature Management Assessment was submitted to NMFS May 1, 2015, an update on June 1, 2015 and a Plan on August 6, 2015 for concurrence. The Plan included an iCPMM temperature model run with the objective to achieve temperature (mean daily) target(s) at Hazel Avenue Bridge and Watt Avenue Bridge. The model run incorporated the latest operation's forecast (inflow, outflow and storage) and iteratively selected a temperature target based on available resources and a pre-assumed habitat balance between steelhead and fall-run Chinook. The selected plan requires NMFS approval, with input from members of the ARG. The plan is reviewed for potential updates every month based on the latest hydrology and cold-water pool conditions. NMFS must concur on proposed deviations from the plan that may reduce the likelihood that the temperature objective will be met. Temperature modeling results are one component that guides the decision making for the Temperature Management Plan. The model results were influenced in water year 2015 due to: extremely low projected storage conditions and small cold-water pool volume, extremely low precipitation/snow-pack and inflow, warmer inflow, system-wide operations including: reduced delivery requirements, winter-run protection/Keswick limited flows and Delta regulatory requirements. Preliminary iCPMM results indicated the warmest ATSP (Automated Temperature Selection Procedure) maximum temperature target (72°F at Watt Avenue Bridge) could not be achieved and was not feasible. The ATSP was modified by iteratively increasing the maximum target temperature until a feasible solution was found. Based on these existing conditions, assumed future conditions, and iterative modeling results (adjusted to accommodate warmer scenarios), the Temperature Management Plan recommended a reasonably feasible maximum mean daily temperature target at Hazel Avenue Bridge of 71 ^{o}F and Watt Avenue Bridge of 75 ^{o}F through September 2015.

Various temperature management options were identified early this year:

- Continue exercising real-time management capabilities,
- Move temperature control upstream of Watt Avenue Bridge to Hazel Avenue Bridge (a technique applied in the Sacramento River for temperature management),
- Delay shutter changes an allow warmer temperatures earlier in the season,
- De-gang shutters to improve temperature performance,
- Strategically use Lower River Outlets/power bypass,
- Coordinate releases with the California State Water Project (SWP) Feather River releases for Delta Management
- Structure potential water transfers and release timing to help lake storage and temperatures

All techniques have or plan to be applied to some degree in an effort to help achieve the best possible temperature performance despite poor conditions.

Low storage conditions in water year 2015 prevented the lowering of the Top set of Temperature Shutters. Further low storage conditions persisted and as a result, Temperature Shutter operations were generally driven not by temperature, but by the elevation /head requirements (due to the risk of structural

damage). Mitigation of this was attempted on two occasions (1) de-ganging of the Middle Temperature Shutter from a two-panel configuration to a one-panel configuration (July 22, 2015), and (2) de-ganging of the Bottom Temperature Shutter from a four-panel configuration to a three-panel configuration (September 9, 2015). These efforts allowed for greater flexibility of temperature blending and suggest potential improvement of efficiency.

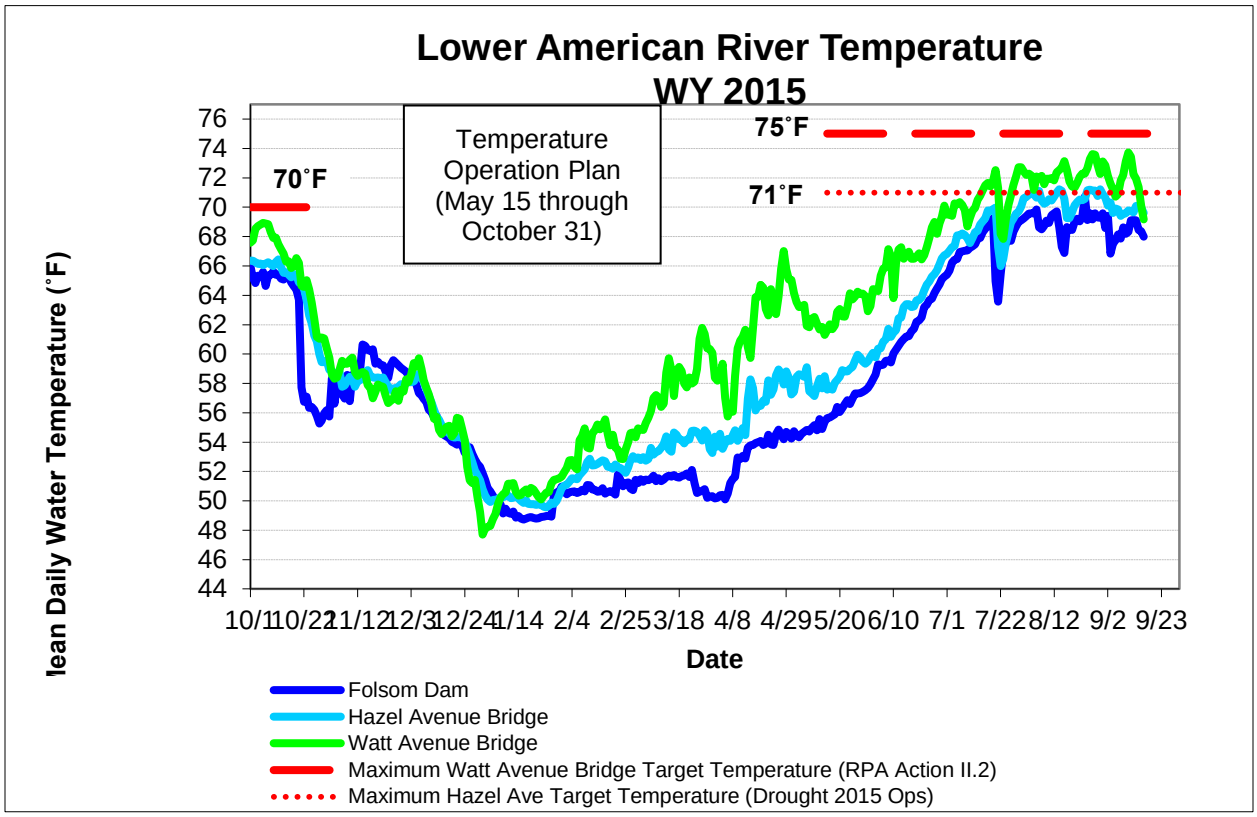

Figure 4. Summary of Temperature in the Lower American River

Table 4 is a list of Folsom Dam temperature shutter and power penstock blending operations taken to meet downstream temperature requirements.

Table 4. Folsom Dam Temperature Shutter and Bypass Operation

Date	Operation
1/28/2015	Lower the Bottom and Middle set of temperature shutters on Folsom Penstocks Unit 1 and Unit 2.
3/24/2015	Raise the Bottom and Middle set of temperature shutters on Folsom Penstocks Unit 2. Comment: Temperature operation supporting steelhead redds
3/28/2015	Bypass the following schedule through the lower-tier River Outlets from 0 cfs to 250 cfs. Comment: Temperature operation supporting steelhead redds
3/29/2015	Bypass the following schedule through the lower-tier River Outlets from 250 cfs to 400 cfs. Comment: Temperature operation supporting steelhead redds
3/30/2015	Bypass the following schedule through the lower-tier River Outlets from 400 cfs to 250 cfs. Comment: Temperature operation supporting steelhead redds
4/1/2015	Raise the Bottom and Middle set of temperature shutters on Folsom Penstocks Unit 1. Comment: Temperature operation supporting steelhead redds
4/6/2015	Please terminate the bypass through the lower-tier river outlets from 250 cfs to 0 cfs.
4/9/2015	Lower the Bottom and Middle set of temperature shutters on Folsom Penstock Units 1 and 2.
7/20/2015	Raise the Middle set of temperature shutters on Folsom Penstock Units 1 and 2.
7/22/2015	The Middle set temperature shutters on Folsom Penstock Unit 2 was de-ganged and one panel lowered.
8/6/2015	Raise the Middle (one Middle panel) temperature shutter on Folsom Penstock Unit 2. Comment: Temperature shutter elevation requirement
8/14/2015	Raise the Bottom set of temperature shutters on Folsom Penstock Unit 2
8/14/2015	Minimize load on Unit 2
8/15/2015	Target Folsom Unit 2 at approximately 10% of the daily load
8/16/2015	Target Folsom Unit 2 at approximately 25% of the daily load
8/17/2015	Target Folsom Unit 2 at approximately 15% of the daily load.
8/19/2015	Target Folsom Unit 2 at approximately 10% of the daily load
8/24/2015	Target Folsom Unit 2 at approximately 0% of the daily load
8/25/2015	Target Folsom Unit 2 at approximately 10% of the daily load
8/27/2015	Target Folsom Unit 2 at approximately 15% of the daily load
9/1/2015	Target Folsom Unit 2 at approximately 20% of the daily load
9/10/2015	The Bottom set temperature shutters were raised on Folsom Penstock Unit 1 and the Bottom set of temperature shutters were de-ganged and 3 panels lowered on Penstock Unit 2. Comment: Temperature shutter elevation requirement
9/10/2015	Target Unit 1 at approximately 0% of the daily load and target Unit 2 at approximately 100 % of the daily load as a result of the shutter change.

4.3 Action II.4 - Minimize Flow Fluctuation Effects

The goal of RPA Action II.4 (NMFS 2009 BiOp) is to reduce stranding and isolation of juvenile steelhead through ramping protocols, from January 1 through May 31; and to minimize the occurrence of flows

exceeding 4,000 cfs throughout the year, except as necessary for flood control or in response to high inflow events.

Ramping protocols as specified under RPA II.4 were met from January 1 through May 31.

Chapter 5 – Lower American River Monitoring

The monitoring activities described below are currently being implemented on the LAR and include actions which are either a requirement in the NMFS 2009 BiOp, assist Reclamation in meeting the NMFS 2009 BiOp RPA requirements, provide supplemental information, or are a CVPIA requirement.

5.1 RPA Monitoring Activities

5.1.1 Steelhead Spawning Surveys

NMFS RPA Actions II.1 – Lower American River Flow Management and II.4 - Minimize Flow Fluctuation Effects

Reclamation contracted with Cramer Fish Sciences to conduct bi-weekly steelhead redd surveys from Nimbus Dam to Watt Ave, covering approximately 18 river miles. The surveys began January 8, 2015, and extended through April 3, 2015. Steelhead redds were observed from January 21- March 20, and steelhead holding on redds were observed January 21- February 8. A total of 11 confirmed steelhead redds were observed. Surveyed redds were recorded from a cataraft, raft or on foot and plotted using GPS and biometric equipment. Updates were sent to NMFS bi-weekly to summarize the findings of the steelhead spawning survey. A total of 86 salmonid redds were observed January 8 to February 19; however, a portion of these were considered to be "unknown" because they could not be associated with a species (i.e., there were no fish observed on these redds). Of these unknown redds, 58 were later categorized as steelhead based on professional opinion, bringing the total number of Steelhead redds to 69. In addition, a model was developed in this analysis to more accurately characterize redds (i.e., associate to species—Chinook salmon, steelhead or lamprey) when no fish are observed in the vicinity of a redd. Figure 5 shows the redds that were observed throughout the 2015 season.

5.1.2 Manual Temperature Profiles

RPA Action II.2 – Lower American River Temperature Management

Twice per month from May through November, Reclamation collects temperature profile data in Folsom Reservoir to assist in meeting RPA Action II.2 – Temperature Management. The temperature profile data are used to model downstream temperatures through the operation season so Reclamation can plan temperature shutter operations to meet the downstream temperature compliance point at Watt Avenue Bridge. Manual temperature profiles are taken at six locations in Folsom Reservoir (see Chapter 4, Section 4.2).

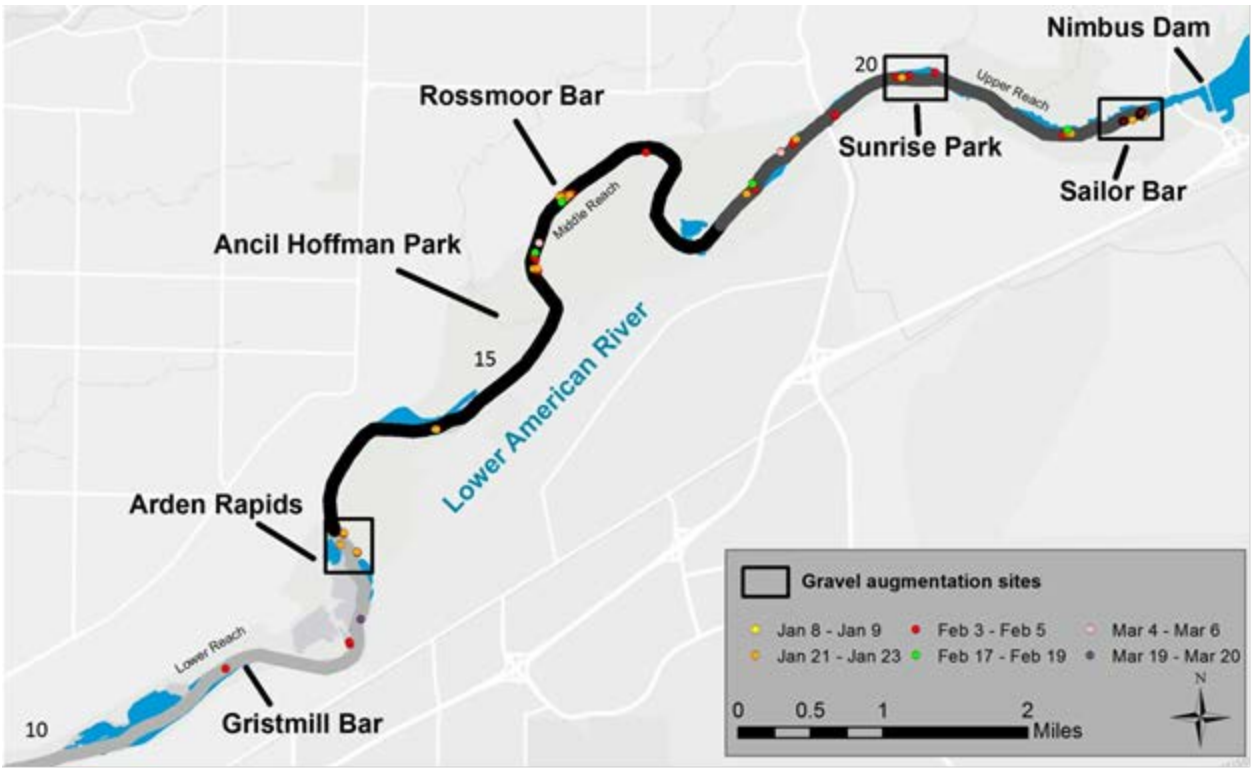

Figure 5. American River Steelhead redd distribution and timing in 2015.

5.1.3 Isolation Pool Monitoring

RPA Action II.4 – Minimize Flow Fluctuation Effects

Reclamation monitors flow fluctuations in the LAR to reduce and assess stranding and isolation of steelhead when ramping down flows and fluctuating flows above and below a threshold where elevations changes could lead to isolation of redds, fry and/or juvenile steelhead. Flow fluctuations in the LAR have been documented to result in steelhead redd dewatering and isolation, fry stranding, and fry and juvenile isolation. Habitat evaluations have identified several locations where isolation of salmonids and other fish species have been observed in the past coinciding with the reduction or fluctuation of flows.

Lower American River stranding surveys were performed on March 24 and 26, April 2-3, and April 15, 2015 following a 300 cubic feet per second (cfs) flow reduction (800 to 500 cfs) from March 24-26 (see Figure 6). The purpose of the survey was to determine if Steelhead redds and/or juvenile salmonids were stranded or dewatered as a result of the flow reduction. During the March 24th survey, flows were near 700 cfs. The March 24, 2015 survey was limited to only the shallowest Steelhead redd observed to date to determine whether it was dewatered as a result of the flow reduction. During the March 24, 2015 survey, flows were near 700 cfs. The same redd was revisited on March 26, 2015, when flows reached 500 cfs, and it was still submerged at a depth of approximately 4 inches. The March 26, 2015 survey also included a stranding survey that encompassed the area from Nimbus Dam to Watt Avenue Bridge. An upstream crew surveyed the area from Nimbus Hatchery downstream to Rossmoor Bar Regional Park and a downstream crew surveyed the area between Rossmoor Bar Regional Park and just above the Watt

Avenue Bridge. Field crew looked for pools that were no longer connected to the river due to the decreased flow, and determined if stranded salmonids were present. If salmonids were observed, the approximate number and size of fish in the isolated pool were recorded, along with a GPS polygon outlining the stranding pool.

Bi-weekly updates were sent to NMFS describing isolation pool observations that coincided with steelhead spawning surveys.

5.1.4 Chinook Redd Dewatering and Pulse Flow Monitoring

Chinook Redd Dewatering Monitoring

Bureau of Reclamation proposed a Folsom/Nimbus Dam flow reduction into the Lower American River (LAR) from ~800 cfs to 500 cfs during week of March 1, 2015--a 100 cfs flow reduction had already occurred between February 18-19. To provide a measurement of impacts to natural LAR Chinook salmon and steelhead production, an assessment was performed of LAR redd dewatering and stranding that may occur from the proposed flow reduction. See the report entitled, "Assessment of Potential Lower American River Chinook Salmon and Steelhead Redd Dewatering Related to a Potential Flow Reduction the Week of March 1, 2015" which was dated February 27, 2015 (see Attachment 1).

Some conclusions of the assessment follow:

The proposed flow reduction period coincided with the end of fall-run Chinook salmon and the middle of steelhead incubation periods. A relatively small number of late-fall Chinook salmon also spawn near the beginning of the steelhead period in some years. It was predicted that the proposed flow reduction from Nimbus Dam could dewater or strand salmonid redds. It was also predicted that embryos within dewatered or stranded redds could become trapped and unable to emerge from the gravel or gain access to the main channel to complete the development, rearing, and emigration process or may actually perish if redds desiccate or water quality surpasses their zone of tolerance. In addition, reduced flow was believed to have a more acute impact on salmon embryos when weather is unusually warm or dry. This is because relatively warm air temperatures and lack of runoff from tributaries downstream of the dam can cause high water temperatures and low dissolved oxygen levels that are stressful or potentially lethal to developing embryos. Furthermore, reduced flow may minimize flushing inter-gravel waters within nests allowing buildup of metabolic wastes that are potentially stressful to developing embryos.

In summary, the report documents the following effects associated with this proposed flow release change:

- An estimated 10-15% of the 2014 fall-run Chinook salmon and 100% of 2014/15 late-fall Chinook and steelhead embryos would likely still be incubating at this time. Steelhead should also continue spawning through the month of March.
- From prior surveys within the 4 monitoring sites (CVPIA gravel augmentation sites), a total of 527 redds (fall-run Chinook: 420; confirmed steelhead: 11; steelhead or late-fall Chinook: 96) were identified.
- From these surveys there is an estimated that 3.8% (SD 2.29) of fall-run Chinook salmon redds that would be dewatered with a reduction to 500 cfs. Steelhead redd counts are relatively low this

year and no redds identified during steelhead surveys appear to be dewatered from the proposed flow reduction.

Intergravel water quality monitoring during the 2014 incubation period suggests a reduction to 500 cfs under the current weather scenario will have negative effects on intergravel water quality. This should be evaluated more fully.

5.2 Other Monitoring Activities

5.2.1 Rotary Screw Trap

Rotary screw traps were deployed 1/8 mile downstream of the Watt Avenue Bridge on the LAR in Sacramento County, California, for 125 days between January 9, 2015 and May 29, 2015. The primary objective of the trapping operations is to gather juvenile Chinook salmon and steelhead data pertaining to fish size, weight, life stage, and abundance/production. Secondary objectives of the trapping operations focus on collecting data on non-salmonid fish species, and gathering data pertaining to salmonid size, temporal presence, and abundance as they relate to environmental factors.

During the 2015 field season, two traps were deployed in one of the two river channels below the Watt Avenue Bridge. The raw catch data for juvenile salmonids collected are based on length-at-date criteria. The application of these criteria on the American River may over estimate the number of spring-run Chinook salmon that are caught. Many of the spring-run salmon listed in the spreadsheet (see Attachment 2) will likely be reclassified as fall-run Chinook salmon after genetics analyses are complete. A total of 282,469 fall-run, 703 spring-run, 30 winter-run, and 3 late-fall-run juvenile Chinook salmon were captured. In addition, 9 juvenile steelhead/rainbow were captured. The outmigration of juvenile fall-run Chinook salmon from the LAR during the 2015 field season peaked between January 29, 2015 and March 7, 2015.

5.2.2 Other Monitoring

Additional project specific fisheries monitoring is being conducted to evaluate spawning and rearing habitat restoration projects. This monitoring includes river-wide Chinook salmon redd surveys, ground based redd surveys at project sites, an assessment of juvenile use of various types of habitat structure, an evaluation of egg incubation survival, evaluation of measured intragravel conditions for egg incubation, and comparisons of habitat availability before and after projects. A structured decision making process is being used to determine future project types and identify monitoring needs.

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Assessment of Potential Lower American River Chinook Salmon and Steelhead Redd Dewatering Related to a Potential Flow Reduction the Week of 1 March 2015.

A Draft Report to the American River Group

By Cramer Fish Sciences
3300 Industrial Blvd., Suite 100, West Sacramento, CA 95691
27 February 2015

Executive Summary

- A flow reduction from 900 to 800 cfs occurred between 18 and 19 February 2015 on the Lower American River. A further flow reduction from 800 to 500 cfs has been proposed for the week of 1 March 2015.
- We estimate that 10-15% of the 2014 fall-run Chinook Salmon and 100% of 2014/15 late-fall Chinook and Steelhead embryos will still be incubating at this time. Steelhead should also continue spawning through the month of March.
- Within 4 monitoring sites (gravel augmentation sites), a total of 527 redds (fall-run Chinook: 420; confirmed steelhead: 11; steelhead or late-fall Chinook: 96) were identified.
- From these surveys we estimated that 3.8% (SD 2.29) of fall-run Chinook Salmon redds would be dewatered with a reduction to 500 cfs. Steelhead redd counts are relatively low this year and no redds identified during steelhead surveys appear to be dewatered from the proposed flow reduction.
- However, intergravel water quality monitoring during the 2014 incubation period suggests a reduction to 500 cfs under the current weather scenario will have negative effects on intergravel water quality. This should be evaluated more fully.

Purpose

The US Bureau of Reclamation has proposed Folsom/Nimbus Dam flow reduction into the Lower American River (LAR) from ~800 cfs to 500 cfs during week of 1 March 2015. A 100 cfs flow reduction already occurred between 18 and 19 February. This period coincides with the end of fall-run Chinook salmon and the middle of steelhead incubation periods. A relatively small number of late-fall Chinook salmon also spawn near the beginning of the steelhead period in some years. Flow reduction from Nimbus Dam may dewater or strand salmonid redds (nests). Embryos within dewatered or stranded redds may become trapped and unable to emerge from the gravel or gain access to the main channel to complete the development, rearing, and emigration process or may actually perish if redds desiccate or water quality surpasses their zone of tolerance. Reduced flow may have a more acute impact on salmon embryos when weather is unusually warm or dry. This is because relatively warm air temperatures and lack of runoff from tributaries downstream of the dam can cause high water temperatures and low dissolved oxygen levels that are stressful or potentially lethal to developing embryos. Furthermore, reduced flow

may minimize flushing inter-gravel waters within nests allowing buildup of metabolic wastes that are potentially stressful to developing embryos.

To provide a measurement of impacts to natural LAR Chinook salmon and steelhead production, our team performed an assessment of LAR redd dewatering and stranding that may occur from the proposed flow reduction. This document provides the results of this assessment.

Methods

To estimate the percent of LAR Chinook salmon and steelhead redds dewatered or otherwise exposed during flow reductions, we made the following assumptions:

1. A combination of GPS points taken along the water's edge from last year's flow reduction surveys and 2D modeling (at 4 restoration sites) could provide an accurate estimate of change in wetted channel area.
2. Overlaying Chinook salmon and steelhead redd GPS coordinates with identified areas of dewatering would accurately identify redds directly exposed during the reduction.
3. An emergence model could estimate when incubating embryos and fry are no longer susceptible to redd dewatering.
4. These observations could be used as an indication of overall redd dewatering.

Site selection

Because the majority of LAR spawning occurs within gravel augmentation areas in the upper reaches of the river, and we have accurate and recent bathymetry of these sites, we sampled dewatered areas within each augmentation site (i.e., Sunrise and Sailor Bar regional parks, Arden Rapids, Nimbus Basin). On-the-ground redd survey data is available for these augmentation sites, and these data were used to identify redd dewatering within gravel augmentation areas.

Delineating dewatered or disconnected areas

Points were recorded at intervals around both dewatered and disconnected areas using a Trimble 6000 Series GeoXT. Each point was logged for at least 20-30 seconds, generating 20-30 separate point measurements. This allowed for greater precision delineating dewatered or disconnected areas. The points were later converted to polygons in ArcMap. For the 2014 (Nimbus Basin) site, CBEC estimated change in water's edge using channel bathymetry and hydro-modeling.

Spawning utilization – Redd Locations

Fall-run Chinook salmon spawning data was obtained from redd surveys performed within the restoration sites between 15 October 2014 and 1 January 2015. Steelhead and late-fall Chinook redd surveys were begun in January and are on-going as of this report.
We used Google Earth aerial photos to overlay redd GPS locations and dewatering polygons in conjunction with ArcMap (ESRI, Redlands, CA) to identify the number and location of redds present in the LAR gravel augmentation sites.

Dewatering Estimates

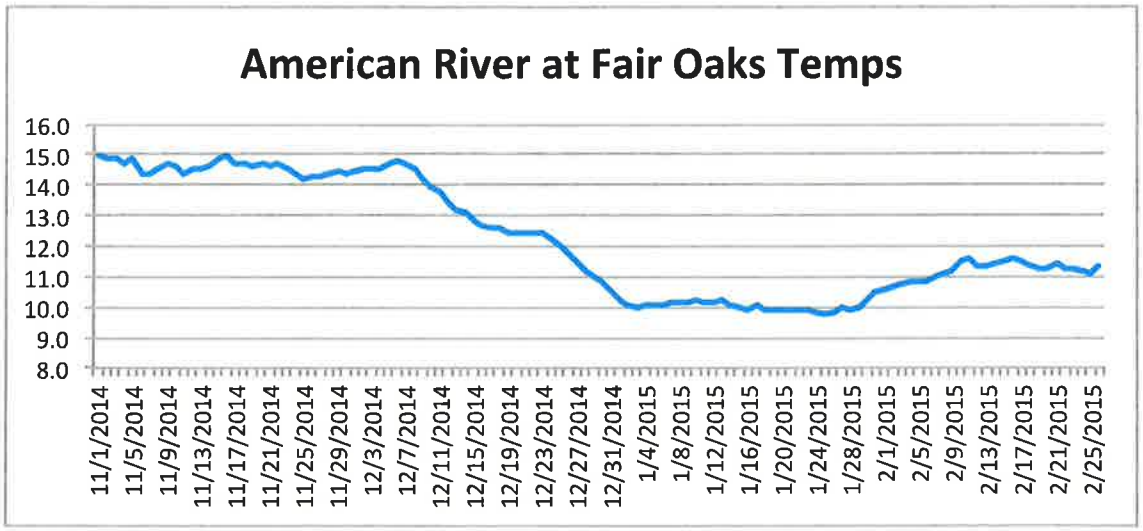
To estimate the incremental effect of flow reduction on Chinook salmon and steelhead redd dewatering at each site, we calculated the total number of redds that became exposed with each subsequent 100 cfs drop in flow level between 800 and 500 cfs (we only have the 300 cfs reduction estimate for 2014 site). For each level of flow reduction, the proportion of dewatered redds was calculated as number of exposed redds over the number of redds still under water

since the previous flow reduction. Confidence intervals were calculated assuming binomial errors in redd observations. Any redd that fell within dewatered or stranded polygons was identified as dewatered. To estimate the cumulative effect of flow reduction on redd dewatering, we summed the total number of redds dewatered with each flow reduction and divided by the total number of redds observed at the beginning of the survey (at a flow of 800 cfs). Again, 95% confidence intervals were calculated assuming binomial errors.

We estimated the incremental proportion of channel dewatered at each site by calculating the area dewatered after each flow reduction by the estimated wetted area from the previous survey for each transect within the reach. Means and standard errors were then calculated for each reach. Cumulative effects were estimated for each reach by summing the dewatered area in each transect for each successive survey and divided by the total wetted area from the initial transect survey (800 cfs). Means and standard errors were then calculated for each reach.

Emergence Model

The BOR (John Hannon) estimated emergence based on the assumption that 900–1,000 thermal units is required for incubation of Pacific salmon eggs (1 T.U. = 1°C above freezing x 24 hours) (Raleigh et al. 1986). Temperatures from the Fair Oaks gauge were used as an indication of what salmonid embryos were exposed to in the LAR.



Results

Channel Dewatering

Figure 1. Redd observations and estimated wetted area at 500 cfs for the Nimbus Basin Restoration Site, 2015.

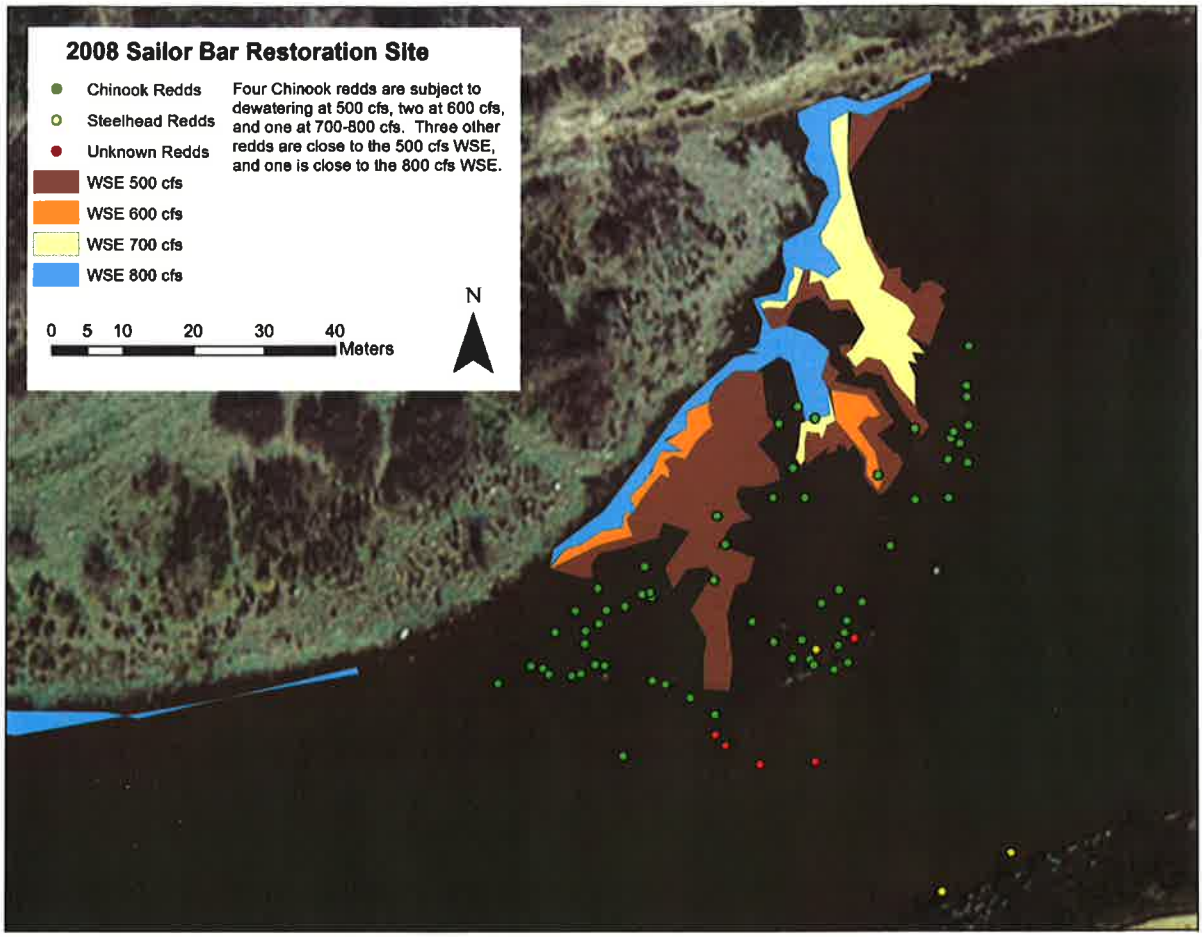


Figure 2. Redd observatinos and estimated dewatering at 4 flow reductions 2015.

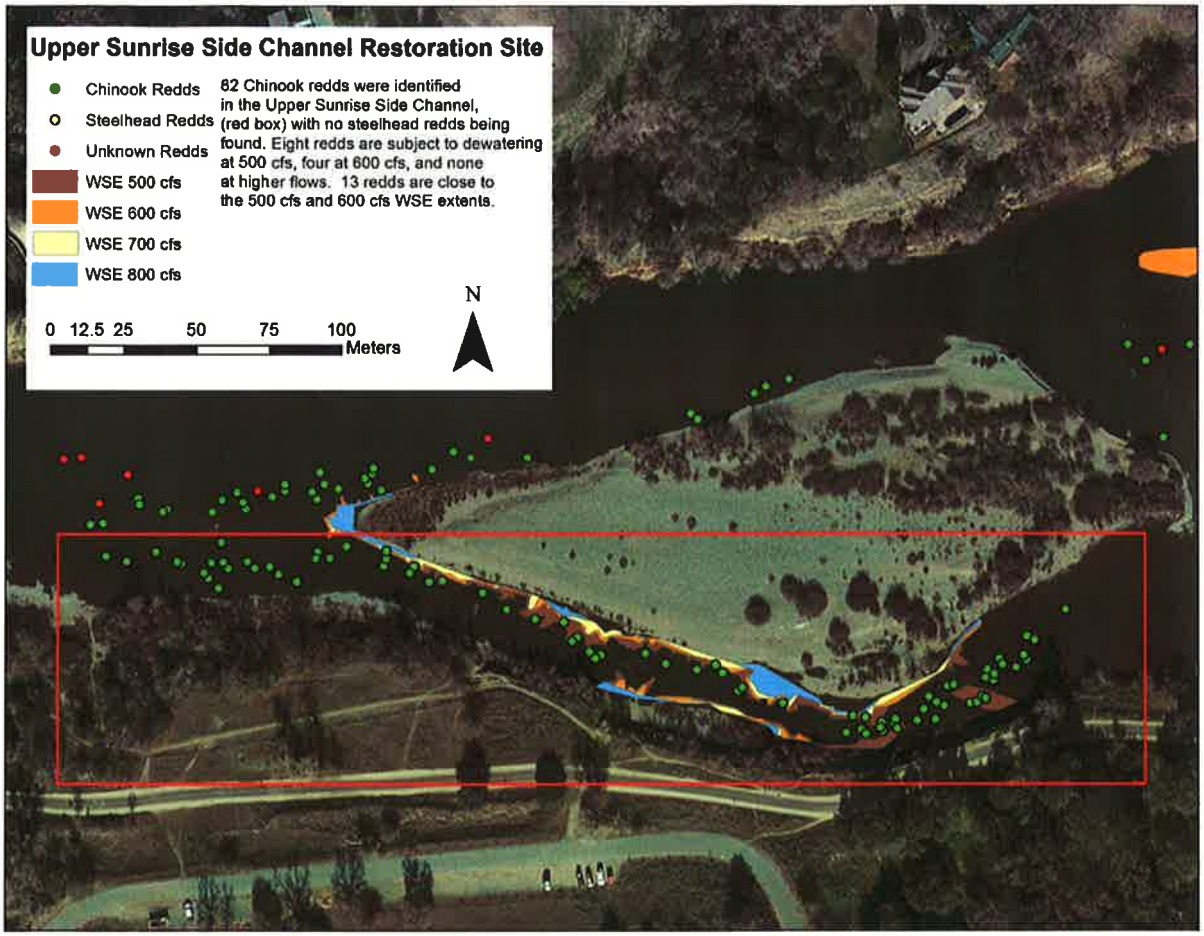


Figure 3. Upper Sunrise Side Channel redd locations and estimated dewatering at 4 flow scenarios, 2015.

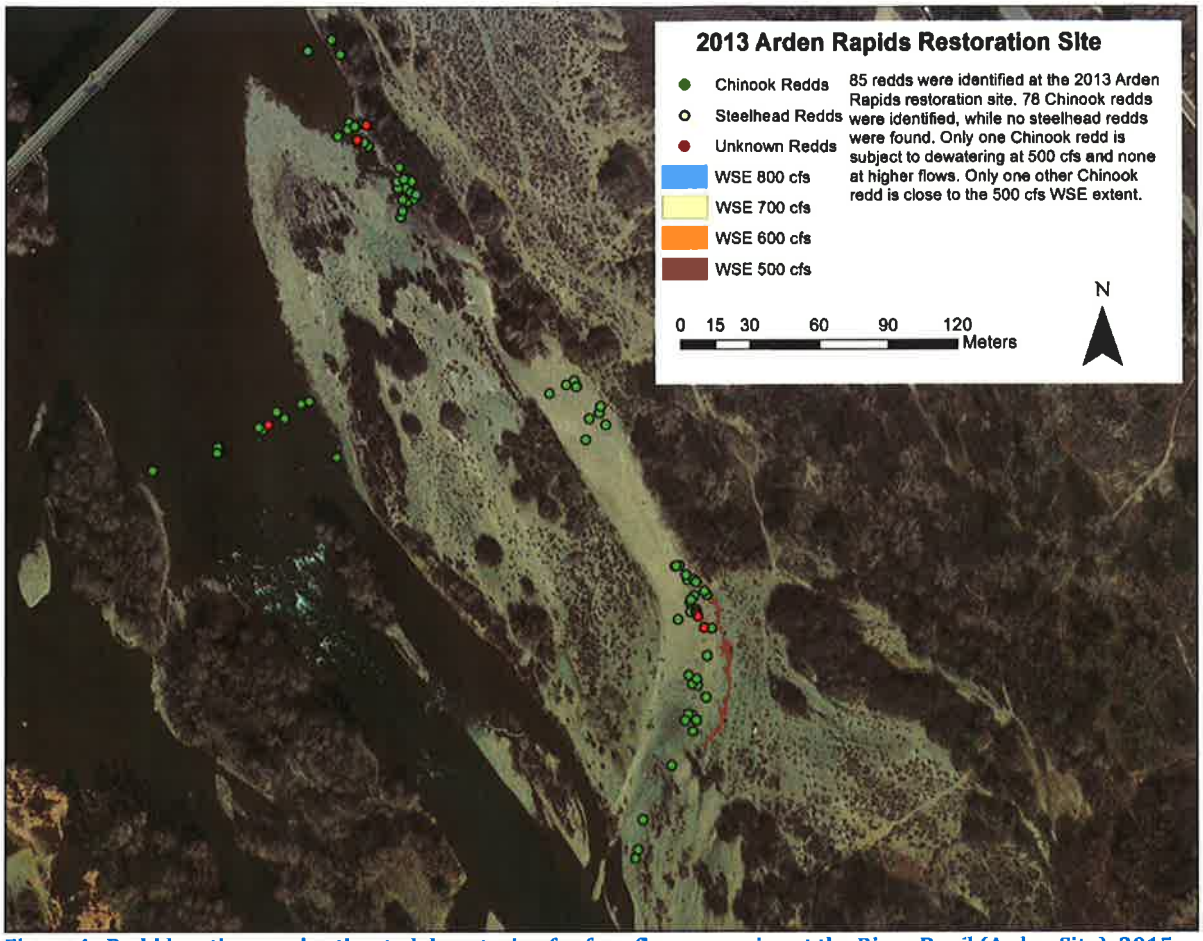


Figure 4. Redd locations and estimated dewatering for four flow scenarios at the River Bend (Arden Site), 2015. Aerial photo is not representative of flows or channel bathymetry during this study.

Spawning utilization – Redd Locations and Estimates

Emergence results

Table 1. Estimated 2015 American River Chinook and steelhead fry emergence dates based on spawning dates using mean daily water temperatures from USGS Fair Oaks Gauge. Actual water temperatures through 2/26/2015 and estimated temperatures after 2/26 based on 2014 temperature data trend.

Chinook	1,000 Temperature Units, C										
Spawn by	1-Nov	7-Nov	14-Nov	21-Nov	28-Nov	5-Dec	12-Dec	19-Dec	26-Dec	1-Jan	21-Jan
Emerge by	16-Jan	25-Jan	4-Feb	13-Feb	22-Feb	3-Mar	11-Mar	19-Mar	26-Mar	31-Mar	15-Apr

Steelhead	600 Temperature Units, C													
Spawn by	1-Jan	8-Jan	15-Jan	22-Jan	29-Jan	5-Feb	12-Feb	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr
Emerge by	26-Feb	4-Mar	10-Mar	16-Mar	22-Mar	27-Mar	2-Apr	8-Apr	14-Apr	20-Apr	25-Apr	1-May	7-May	13-May

From past redd survey data for fall-run Chinook Salmon, we estimate that 10-15% of fall-run Chinook Salmon embryos will still be incubating during the week of 1 March 2015. This will drop to an estimated 5% by the week of 8 March. Fall-run emergence should be complete by 26

March. We estimate that no late-fall Chinook Salmon or Steelhead will have emerged by 1 March.

Table 2. Observed number of fall- and late-fall Chinook Salmon and Steelhead redds within 4 enhancement sites of the Lower American River. Late-Fall and Steelhead have overlapping spawning periods. Therefore, several redds could not be positively identified to species.

No information on extent of dewatering at other flows

2014 Site	Total	Dewatered 500cfs	% @ 500cfs
Total Redds	78	3	3.85
Chinook	55	3	5.45
Steelhead	2	0	0.00
Unknown	21	0	0.00

2008 Site	Total	Dewatered 500cfs	% @ 500cfs	Dewatered 600cfs	% @ 600cfs	Dewatered 700cfs	% @ 700cfs	Dewatered 800cfs	% @ 800cfs
Total redds	71	4	5.63	2	2.82	1	1.41	1	1.41
Chinook	63	4	6.35	2	3.17	1	1.59	1	1.59
Steelhead	3	0	0.00	0	0.00	0	0.00	0	0.00
Unknown	5	0	0.00	0	0.00	0	0.00	0	0.00

Side Channel and Main Channel Included Upper Sunrise Side Channel Site	Total	Dewatered 500cfs	% @ 500cfs	Dewatered 600cfs	% @ 600cfs	Dewatered 700cfs	% @ 700cfs	Dewatered 800cfs	% @ 800cfs
All Redds	151	8	5.30	4	2.65	0	0.00	0	0.00
Chinook	143	8	5.59	4	2.80	0	0.00	0	0.00
Steelhead	0	0	0.00	0	0.00	0	0.00	0	0.00
Unknown	8	0	0.00	0	0.00	0	0.00	0	0.00
Within Upper Sunrise Side Channel Only		Dewatered		Dewatered		Dewatered		Dewatered	
All Redds	82	8	9.76	4	4.88	0	0.00	0	0.00
Chinook	82	8	9.76	4	4.88	0	0.00	0	0.00
Steelhead	0	0	0.00	0	0.00	0	0.00	0	0.00
Unknown	8	0	0.00	0	0.00	0	0.00	0	0.00

2013 Site	Total	Dewatered 500cfs	% @ 500cfs	Dewatered 600cfs	% @ 600cfs	Dewatered 700cfs	% @ 700cfs	Dewatered 800cfs	% @ 800cfs
All redds	85	1	1.18	0	0.00	0	0.00	0	0.00
Chinook	78	1	1.28	0	0.00	0	0.00	0	0.00
Steelhead	0	0	0.00	0	0.00	0	0.00	0	0.00
Unknown	7	0	0.00	0	0.00	0	0.00	0	0.00

Table 3. Total observed number of fall- and late-fall Chinook Salmon and Steelhead redds within 4 enhancement sites of the Lower American River. Late-Fall and Steelhead have overlapping spawning periods. Therefore, several redds could not be positively identified to species. Numbers in parentheses are standard deviation.

All Four Sites	Total	Dewatered 500cfs	% @ 500cfs	Dewatered 600cfs	% @ 600cfs	Dewatered 700cfs	% @ 700cfs	Dewatered 800cfs	% @ 800cfs
Total Redds (New and Fish on) in River	527	16 (2.94)	3.04 (2.03)	6	1.14	1	0.19	1	0.19
Chinook	420	16 (2.94)	3.81 (2.29)	6	1.43	1	0.24	1	0.24
Steelhead	11	0	0	0	0	0	0	0	0
Unknown	96	0	0	0	0	0	0	0	0

These calculations do not include the 2014 Nimbus Basin site

Intergravel water quality

Two of the most important drivers of salmonid embryo survival and development are water temperature and dissolved oxygen. These two variables are inversely related, thus sub-optimal temperatures are often followed by sub-optimal dissolved oxygen concentrations. During the 2014 flow reduction, dewatered areas consistently had higher temperatures and lower dissolved

oxygen concentrations. Temperatures in dewatered redds exceeded levels known to cause stress to embryos 2 weeks sooner than redds that remained connected to the main channel (Figure 5). The 2014 flow reduction occurred early in the incubation period (January) when air temperatures were still cool. A reduction later in the incubation period when air temperatures are warming may result in a more rapid exceedance of embryo temperature tolerance in dewatered redds.

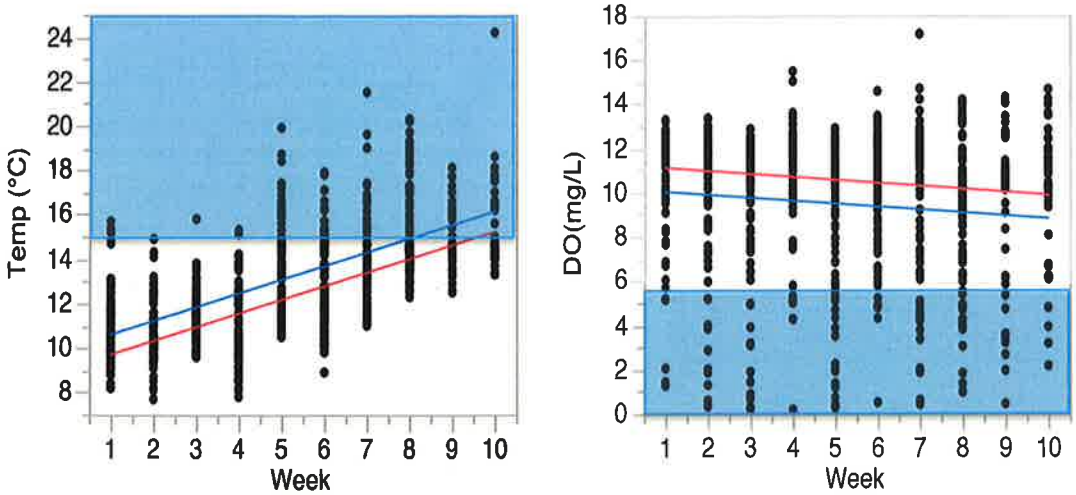


Figure 5. Plot of temperature and dissolved oxygen concentration in dewatered (blue line) and connected (red line) habitats following the initial flow reduction in January 2014. Blue boxes indicate zones of stress.

Lower American River Rotary Screw Trap Daily Catch Summaries at Watt Avenue
January - June 2015

Date	Unmarked Chinook Salmon											Unmarked Steelhead								
	Live Fall	Dead Fall	Live Spring	Dead Spring	Live Winter	Dead Winter	Live Late-fall	Dead Late-fall	**Total CS Catch**	Live Fry	Dead Fry	Live Smolts	Dead Smolts	Live Adults	Dead Adults	**Total SH Catch**
	Overall Catch Totals															
	270,476	11,993	692	11	28	2	3	0	**283,205**	7	0	2	0	2	0	**11**
Jan-9-15	7	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
Jan-10-15	6	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
Jan-11-15	10	3	0	0	1	0	0	0	14	0	0	0	0	0	0	0
Jan-12-15	40	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0
Jan-13-15	79	10	0	0	0	0	0	0	89	0	0	0	0	0	0	0
Jan-14-15	111	9	0	0	1	0	0	0	121	0	0	0	0	0	0	0
Jan-15-15	193	8	0	0	0	0	0	0	201	0	0	0	0	0	0	0
Jan-16-15	140	3	1	0	0	0	0	0	144	0	0	0	0	0	0	0
Jan-17-15	108	3	0	0	0	0	0	0	111	0	0	0	0	0	0	0
Jan-18-15	130	13	0	0	0	0	0	0	143	0	0	0	0	1	0	1
Jan-19-15	184	11	0	0	0	0	0	0	195	0	0	0	0	0	0	0
Jan-20-15	237	5	0	0	0	0	0	0	242	0	0	1	0	0	0	1
Jan-21-15	502	2	0	0	0	0	0	0	504	0	0	0	0	0	0	0
Jan-22-15	759	7	0	0	1	0	0	0	767	0	0	0	0	0	0	0
Jan-23-15	904	6	0	0	0	0	0	0	910	0	0	0	0	0	0	0
Jan-24-15	732	2	0	0	0	0	0	0	734	0	0	0	0	0	0	0
Jan-25-15	895	4	0	0	0	0	0	0	899	0	0	0	0	0	0	0
Jan-26-15	1,785	8	0	0	0	0	0	0	1,793	0	0	0	0	0	0	0
Jan-27-15	550	8	0	0	0	0	0	0	558	0	0	0	0	0	0	0
Jan-28-15	1,431	6	0	0	0	0	0	0	1,437	0	0	0	0	0	0	0
Jan-29-15	2,125	28	0	0	0	0	0	0	2,153	0	0	0	0	0	0	0
Jan-30-15	3,366	16	1	0	1	0	0	0	3,384	0	0	0	0	0	0	0
Jan-31-15	5,227	17	1	0	0	0	0	0	5,245	0	0	0	0	0	0	0
Feb-1-15	4,475	25	1	0	4	0	0	0	4,505	0	0	0	0	0	0	0
Feb-2-15	4,570	18	1	0	0	1	0	0	4,590	0	0	0	0	0	0	0
Feb-3-15	6,417	37	0	0	0	0	0	0	6,454	0	0	0	0	0	0	0
Feb-4-15	4,727	19	0	0	0	0	0	0	4,746	0	0	0	0	0	0	0
Feb-5-15	2,455	16	0	0	0	0	0	0	2,471	0	0	0	0	0	0	0
Feb-6-15	510	0	0	0	0	0	0	0	510	0	0	0	0	0	0	0
Feb-7-15	3,144	13	0	0	0	0	0	0	3,157	0	0	0	0	0	0	0
Feb-8-15	4,138	225	0	0	0	0	0	0	4,363	0	0	0	0	0	0	0
Feb-9-15	10,721	9,691	0	0	0	0	0	0	20,412	0	0	0	0	0	0	0
Feb-10-15	23,412	108	0	0	0	0	0	0	23,520	0	0	0	0	0	0	0
Feb-11-15	14,422	85	0	0	0	1	0	0	14,508	0	0	0	0	0	0	0
Feb-12-15	8,324	46	5	0	4	0	0	0	8,379	0	0	0	0	0	0	0
Feb-13-15	7,623	32	12	0	0	0	0	0	7,667	0	0	0	0	0	0	0
Feb-14-15	5,490	24	7	0	3	0	0	0	5,524	0	0	0	0	0	0	0

Feb-15-15	4,636	26	4	0	2	0	0	0	4,668	0	0	0	0	0	0	0
Feb-16-15	4,878	25	4	0	0	0	0	0	4,907	0	0	0	0	1	0	1
Feb-17-15	3,553	25	0	0	0	0	0	0	3,578	0	0	0	0	0	0	0
Feb-18-15	3,813	11	0	0	0	0	0	0	3,824	0	0	0	0	0	0	0
Feb-19-15	3,957	18	2	0	0	0	0	0	3,977	0	0	0	0	0	0	0
Feb-20-15	1,020	18	1	0	0	0	0	0	1,039	0	0	0	0	0	0	0
Feb-21-15	2,046	14	1	0	2	0	0	0	2,063	0	0	0	0	0	0	0
Feb-22-15	4,306	191	0	0	0	0	0	0	4,497	0	0	0	0	0	0	0
Feb-23-15	4,454	17	0	0	1	0	0	0	4,472	0	0	0	0	0	0	0
Feb-24-15	5,919	32	1	0	2	0	0	0	5,954	0	0	0	0	0	0	0
Feb-25-15	7,470	50	2	0	1	0	0	0	7,523	0	0	0	0	0	0	0
Feb-26-15	7,764	35	1	0	1	0	0	0	7,801	0	0	0	0	0	0	0
Feb-27-15	8,737	34	0	0	0	0	0	0	8,771	0	0	0	0	0	0	0
Feb-28-15	4,807	19	4	0	0	0	0	0	4,830	0	0	0	0	0	0	0
Mar-1-15	10,511	61	0	0	0	0	0	0	10,572	0	0	0	0	0	0	0
Mar-2-15	13,429	76	0	0	1	0	0	0	13,506	0	0	0	0	0	0	0
Mar-3-15	11,758	75	3	0	0	0	0	0	11,836	2	0	0	0	0	0	2
Mar-4-15	16,117	74	5	0	1	0	0	0	16,197	0	0	0	0	0	0	0
Mar-5-15	10,688	54	2	0	0	0	0	0	10,744	1	0	0	0	0	0	1
Mar-6-15	6,385	21	1	0	0	0	0	0	6,407	0	0	0	0	0	0	0
Mar-7-15	4,462	62	1	0	0	0	0	0	4,525	1	0	0	0	0	0	1
Mar-8-15	1,238	8	1	0	1	0	0	0	1,248	0	0	0	0	0	0	0
Mar-9-15	734	17	0	0	0	0	0	0	751	0	0	0	0	0	0	0
Mar-10-15	376	14	3	0	0	0	0	0	393	0	0	0	0	0	0	0
Mar-11-15	76	8	4	0	0	0	0	0	88	0	0	0	0	0	0	0
Mar-12-15	245	8	2	0	0	0	0	0	255	0	0	0	0	0	0	0
Mar-13-15	110	10	2	0	0	0	0	0	122	0	0	0	0	0	0	0
Mar-14-15	114	9	2	0	0	0	0	0	125	0	0	0	0	0	0	0
Mar-15-15	139	12	0	0	0	0	0	0	151	0	0	0	0	0	0	0
Mar-16-15	70	5	1	0	0	0	0	0	76	0	0	0	0	0	0	0
Mar-17-15	62	4	1	0	0	0	0	0	67	0	0	0	0	0	0	0
Mar-18-15	84	9	5	0	0	0	0	0	98	0	0	0	0	0	0	0
Mar-19-15	120	4	14	0	0	0	0	0	138	0	0	0	0	0	0	0
Mar-20-15	115	4	5	0	0	0	0	0	124	0	0	0	0	0	0	0
Mar-21-15																
Mar-22-15																
Mar-23-15	82	1	10	0	0	0	0	0	93	0	0	0	0	0	0	0
Mar-24-15	114	1	12	0	0	0	0	0	127	0	0	0	0	0	0	0
Mar-25-15	91	1	18	0	0	0	0	0	110	0	0	0	0	0	0	0
Mar-26-15	100	0	11	0	1	0	0	0	112	0	0	0	0	0	0	0
Mar-27-15	207	23	40	2	0	0	0	0	272	0	0	0	0	0	0	0
Mar-28-15																
Mar-29-15																
Mar-30-15	293	55	35	0	0	0	0	0	383	0	0	0	0	0	0	0
Mar-31-15	313	6	24	0	0	0	0	0	343	0	0	0	0	0	0	0
Apr-1-15	722	35	85	1	0	0	0	0	843	0	0	0	0	0	0	0
Apr-2-15	789	114	85	6	0	0	0	0	994	0	0	0	0	0	0	0
Apr-3-15	884	116	59	0	0	0	0	0	1,059	0	0	0	0	0	0	0
Apr-4-15																
Apr-5-15																
Apr-6-15	601	0	54	0	0	0	0	0	655	0	0	0	0	0	0	0
Apr-7-15	130	2	18	0	0	0	0	0	150	0	0	0	0	0	0	0
Apr-8-15	401	0	33	0	0	0	0	0	434	0	0	0	0	0	0	0
Apr-9-15	240	1	27	0	0	0	0	0	268	0	0	0	0	0	0	0
Apr-10-15	101	0	6	0	0	0	0	0	107	0	0	0	0	0	0	0
Apr-11-15																
Apr-12-15																
Apr-13-15	92	1	2	0	0	0	0	0	95	0	0	0	0	0	0	0
Apr-14-15	99	14	6	0	0	0	0	0	119	0	0	0	0	0	0	0

Apr-15-15	101	1	12	0	0	0	0	0	114	0	0	0	0	0	0	0
Apr-16-15	64	4	4	0	0	0	0	0	72	0	0	0	0	0	0	0
Apr-17-15	98	0	3	0	0	0	1	0	102	0	0	0	0	0	0	0
Apr-18-15																
Apr-19-15																
Apr-20-15	52	10	1	2	0	0	0	0	65	0	0	0	0	0	0	0
Apr-21-15	52	3	0	0	0	0	0	0	55	0	0	0	0	0	0	0
Apr-22-15	46	0	14	0	0	0	0	0	60	0	0	0	0	0	0	0
Apr-23-15	44	2	3	0	0	0	0	0	49	1	0	0	0	0	0	1
Apr-24-15	64	1	7	0	0	0	0	0	72	0	0	0	0	0	0	0
Apr-25-15																
Apr-26-15																
Apr-27-15	80	7	4	0	0	0	0	0	91	0	0	0	0	0	0	0
Apr-28-15	82	0	3	0	0	0	0	0	85	0	0	0	0	0	0	0
Apr-29-15	67	0	2	0	0	0	0	0	69	1	0	0	0	0	0	1
Apr-30-15	65	30	5	0	0	0	0	0	100	0	0	0	0	0	0	0
May-1-15	43	1	2	0	0	0	0	0	46	0	0	0	0	0	0	0
May-2-15																
May-3-15																
May-4-15	40	0	3	0	0	0	0	0	43	0	0	1	0	0	0	1
May-5-15	28	0	1	0	0	0	0	0	29	1	0	0	0	0	0	1
May-6-15	17	2	0	0	0	0	1	0	20	0	0	0	0	0	0	0
May-7-15	20	2	0	0	0	0	0	0	22	0	0	0	0	0	0	0
May-8-15	22	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0
May-9-15																
May-10-15																
May-11-15	13	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0
May-12-15	8	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
May-13-15	11	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0
May-14-15	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
May-15-15	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
May-16-15																
May-17-15																
May-18-15	5	2	1	0	0	0	0	0	8	0	0	0	0	0	0	0
May-19-15	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
May-20-15	10	0	0	0	0	0	1	0	11	0	0	0	0	0	0	0
May-21-15	8	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
May-22-15	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
May-23-15																
May-24-15																
May-25-15																
May-26-15	6	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
May-27-15	6	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
May-28-15	4	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0
May-29-15	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0