Jacobs Challenging today. Reinventing tomorrow.

Sacramento River, Sutter Bypass, and Yolo Bypass Floodplain Rearing Habitat Evaluations

Supporting Sites Reservoir Project Planning and Scenario Development

2022 CWEMF Conference

04/06/2022

Jeremy Thomas & Chad Whittington / Jacobs

Outline

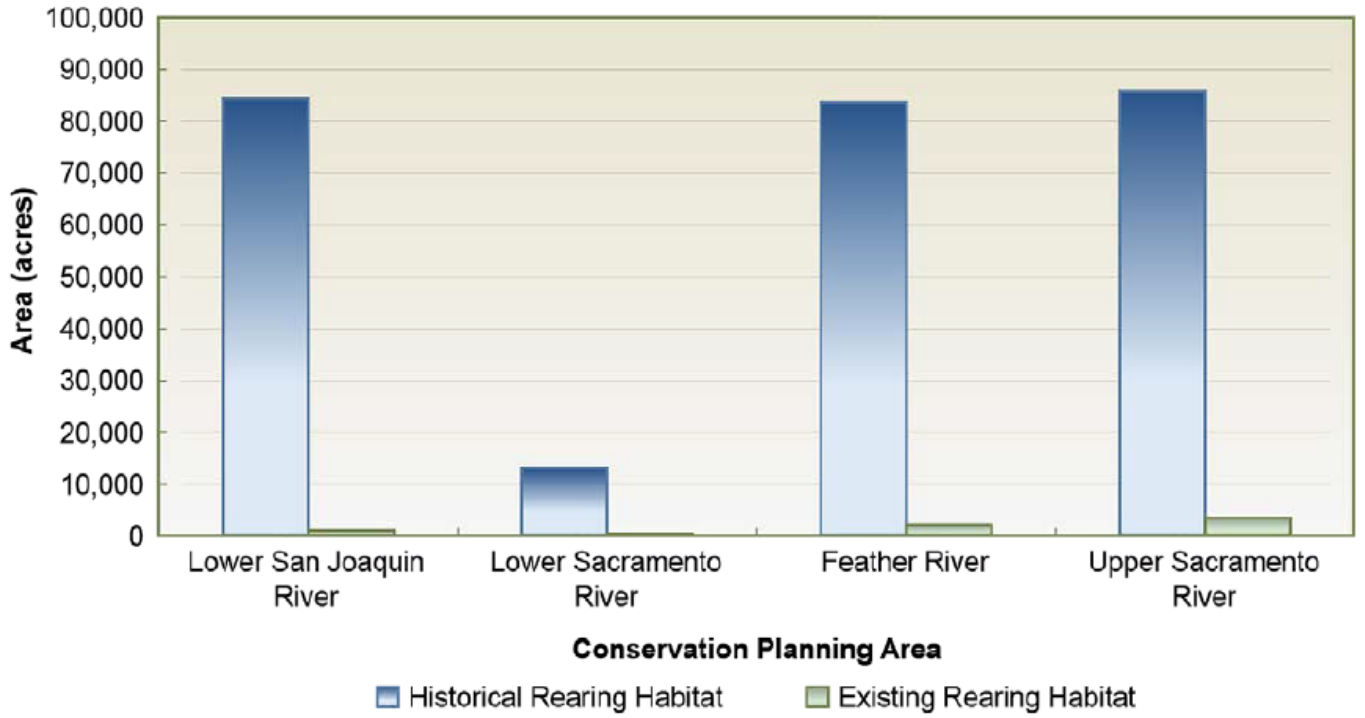
1. Objectives and Background
2. Approach
3. Preliminary Results and Trends
4. Findings
5. Questions

Study Objectives

- Identify range of potentially suitable salmonid rearing habitat on existing floodplains along three primary segments of the Sacramento River:
  - Mainstem channel from Bend Bridge to Knight's Landing
  - Sutter Bypass
  - Yolo Bypass
- Compare changes in floodplain rearing habitat between existing conditions and potential future conditions associated with Sites Reservoir operations
- Identify potential impacts or benefits to juvenile salmonids

Ecological Goals and Opportunities

- *Maximize growth of juvenile salmonids from emergence to successful migration to the ocean*
- *Understand how we can design and operate Sites Reservoir to optimize the utilization of floodplain habitats by juvenile salmonids*

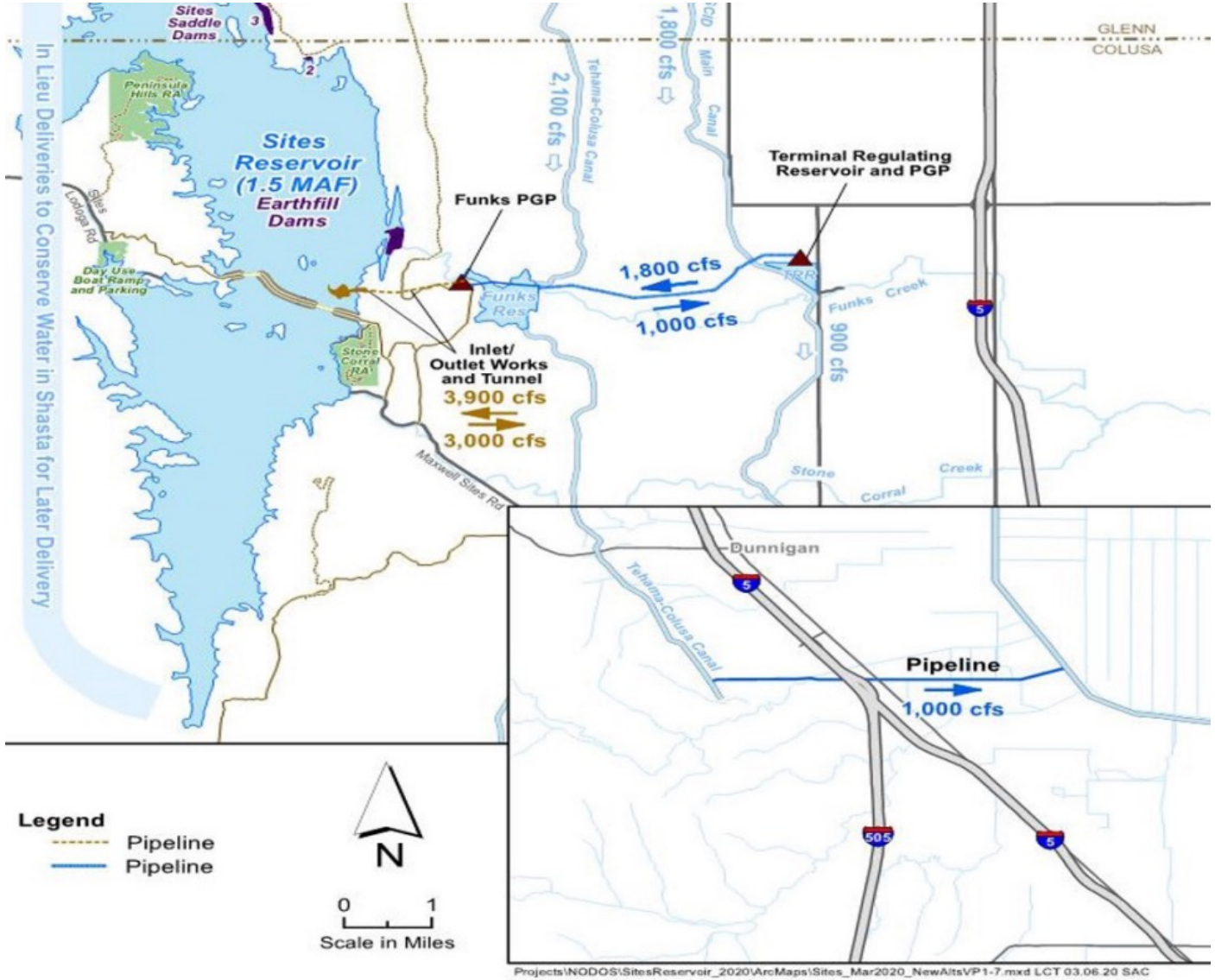


Study Approach

1. Identify juvenile salmonid floodplain rearing habitat criteria
2. Use USRDOM and CalSim to model historical and simulated hydrology for 82 years
3. Develop and configure 1-D and 2-D hydraulic models to determine flow conditions that meet floodplain rearing habitat criteria
4. Produce maps and quantify areas of inundation
5. Compare frequency of floodplain inundation events - historical to with-project operations
6. Perform biological impact or benefit analyses based on changes in floodplain rearing habitat

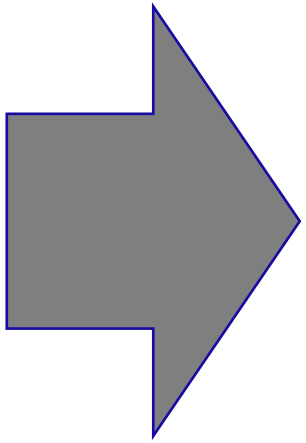
Sites Project Description

- Sites Reservoir, new off-stream reservoir west of Maxwell, California to capture excess water and store the water to use in dry periods
- Existing infrastructure to divert and convey unregulated and unappropriated flow from the Sacramento River (at Red Bluff and Hamilton City) to Sites Reservoir
- Releases from Sites Reservoir would ultimately return to the Sacramento River system via existing canals and a new pipeline located near Dunnigan
- Diversions to storage typically occur in the winter and releases typically occur in the spring through summer
- Membership/Participation of Sites Project is based on a share of storage: water allocation proportional to storage share



Habitat Suitability Criteria

- Water Depths ≤ 1 meter
- Water Velocities ≤ 1.5 ft/s
- Suitable Land Cover Types:
  - Agriculture
  - Seasonal Wetlands
  - Non-tidal Marsh
  - Riparian Scrub and Forest
  - Gravel Bar (Active Channel)
  - Open Water
- Hydrology
  - Timing: November 1 – June 30
  - Duration: 8 to 17 days - suitable habitat
    18 to 24 days - optimal habitat



Developed from existing habitat suitability research / models:

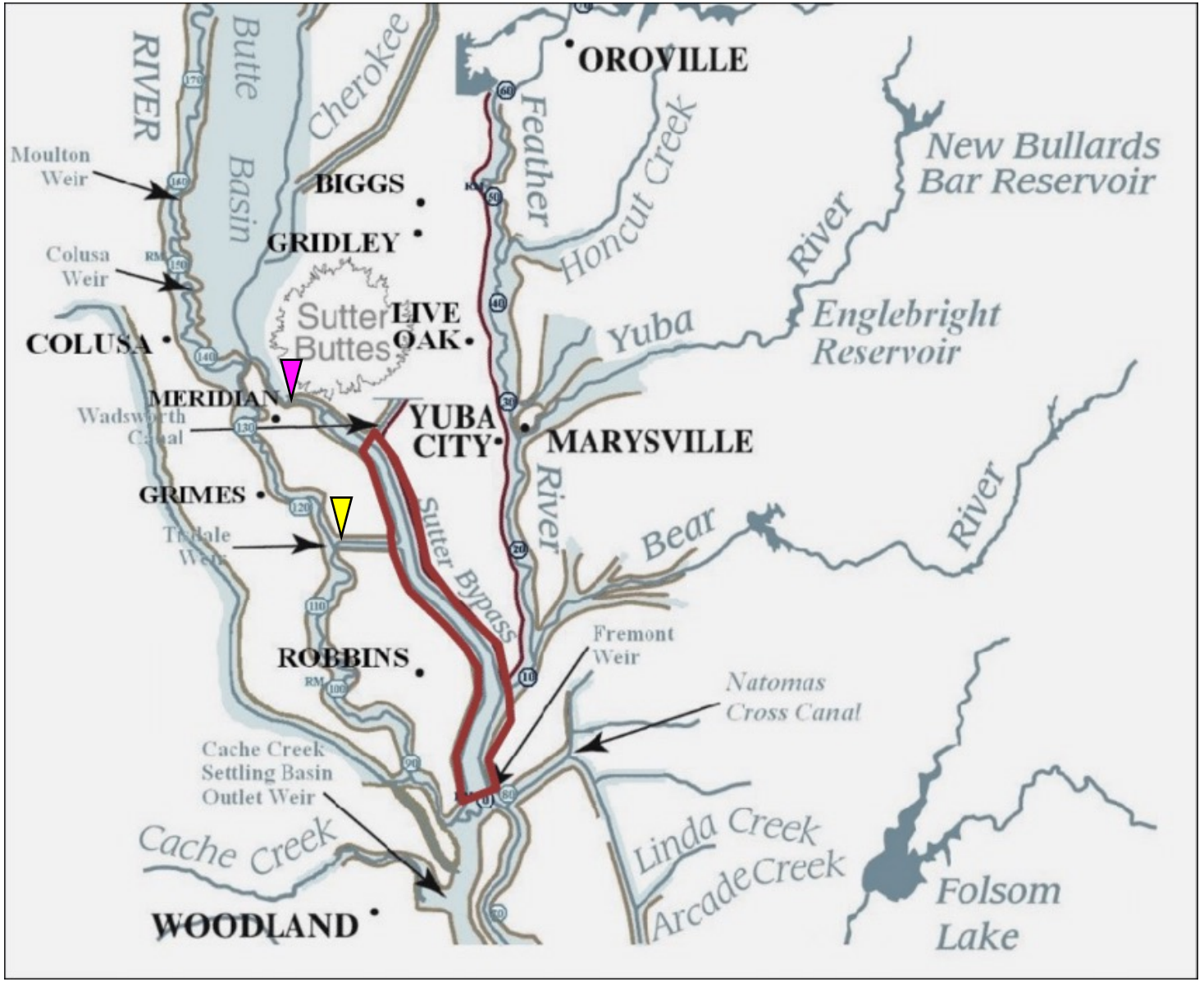
- 2019 Chinook Salmon Habitat Quantification Tool (i.e. Salmon HQT)
- USFWS habitat suitability models
- CVFPP Conservation Strategy and appendices
- Empirical studies on Trinity River restoration sites (1997)

Hydrologic & Hydraulic Modeling

- 3 HEC-RAS models developed for the following:
  - Sutter Bypass
  - Yolo Bypass
  - Main Channel of the Sacramento River
- Boundary conditions for each model were established based on analyses of simulated and historic flows
  - Correlations between river flows and weir spills
  - Flow and spill frequency and duration analysis
- Flow vs habitat area curves were developed from HEC-RAS results
  - Used to evaluate the effects of Sites Project operations on suitable habitat area

Inflow location –
weir spill & unregulated

Inflow location –
weir / control structure



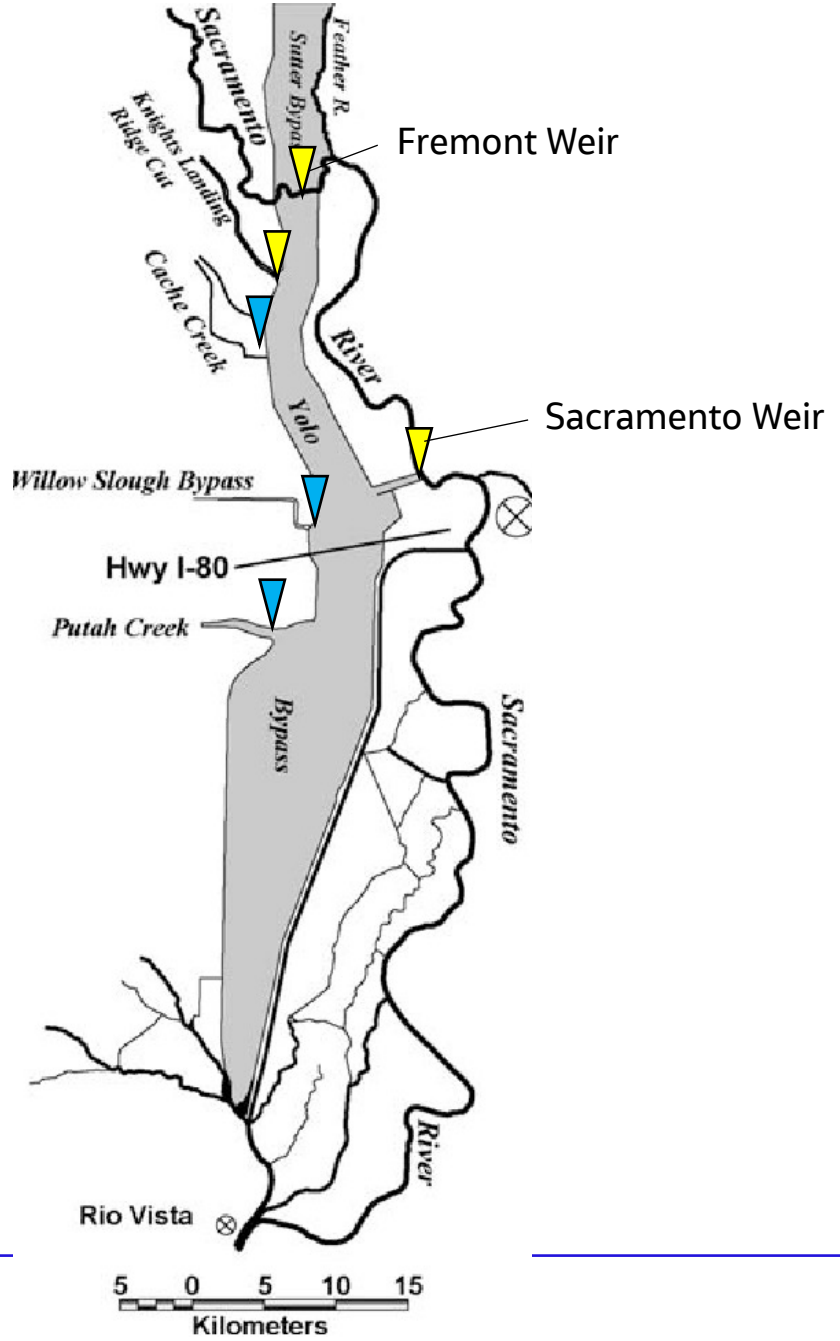
Modeling Methods – Sutter Bypass

- Sensitivity analyses performed for various Sutter Bypass flows determining which flows through Butte Slough and Tisdale Weir satisfy biological criteria (velocity and depth)
- 16 scenarios developed that bracket the range of events that satisfy both criteria, with the following range of inflows and total flows
- Maps developed showing total acreage of inundation for each land cover type for each scenario

Tisdale Weir (cfs)	Butte Slough (cfs)	Total Sutter Bypass (cfs)
0-1,000	500 – 7,000	500 – 8,000

Inflow location - unregulated

Inflow location – weir / control structure



Fremont Weir

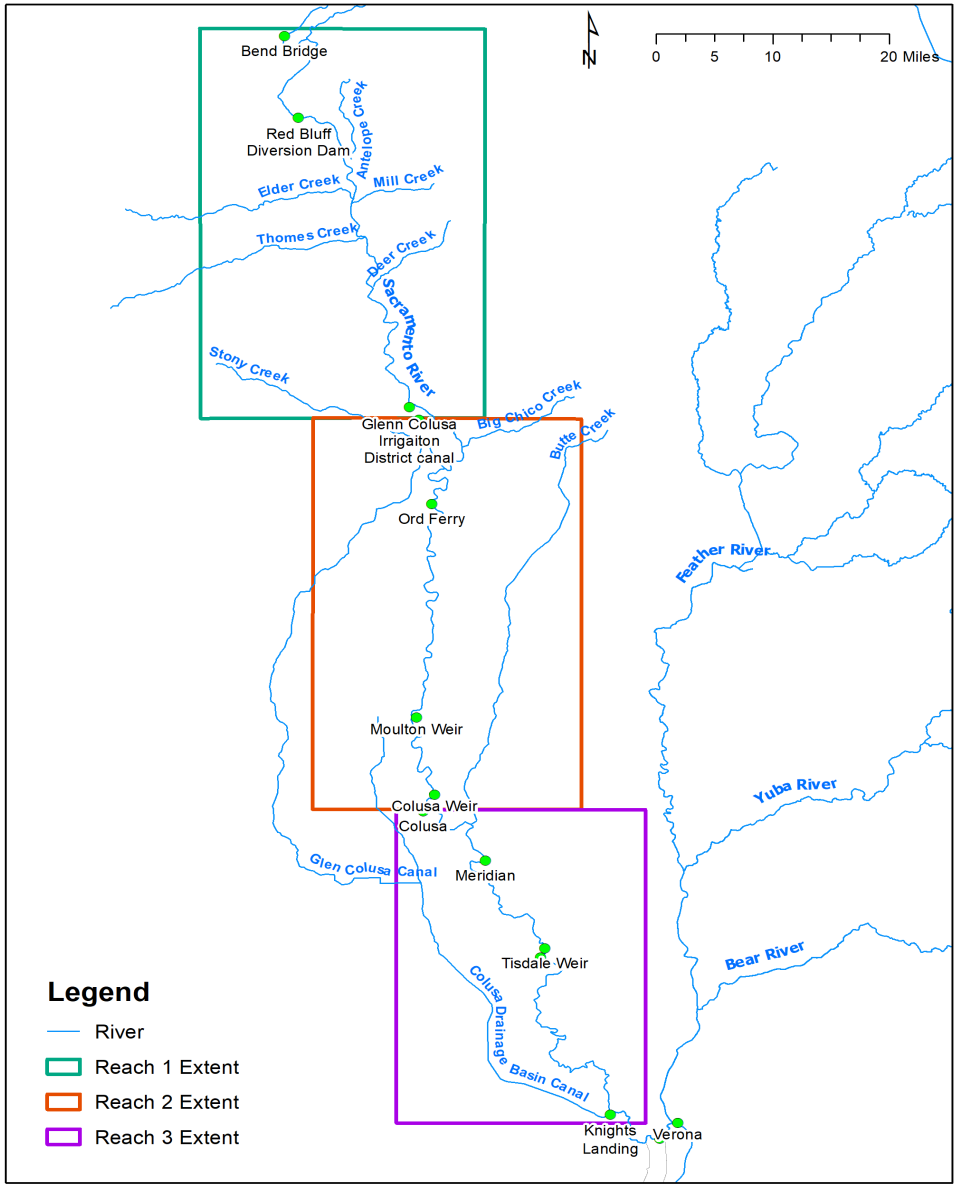
Sacramento Weir

Modeling Methods – Yolo Bypass

- Sensitivity analyses performed for various Yolo Bypass flows determining which flows from the Westside tributaries (Knight's Landing Ridge Cut, Cache Creek, Willow Slough, Putah Creek) and Fremont Weir satisfy biological criteria (velocity and depth)
- 8 scenarios developed that bracket the range of events that satisfy both criteria, with the following range of inflows and total flows
- Maps developed showing total acreage of inundation for each land cover type for each scenario

West Side Tributaries (cfs)	Fremont Weir (cfs)	Total Yolo Bypass (cfs)
930-6,200	0 – 15,000	930 – 21,200

Sites Suitable Habitat Analysis
River Reach Locations



Sites EIR/EIS 2020

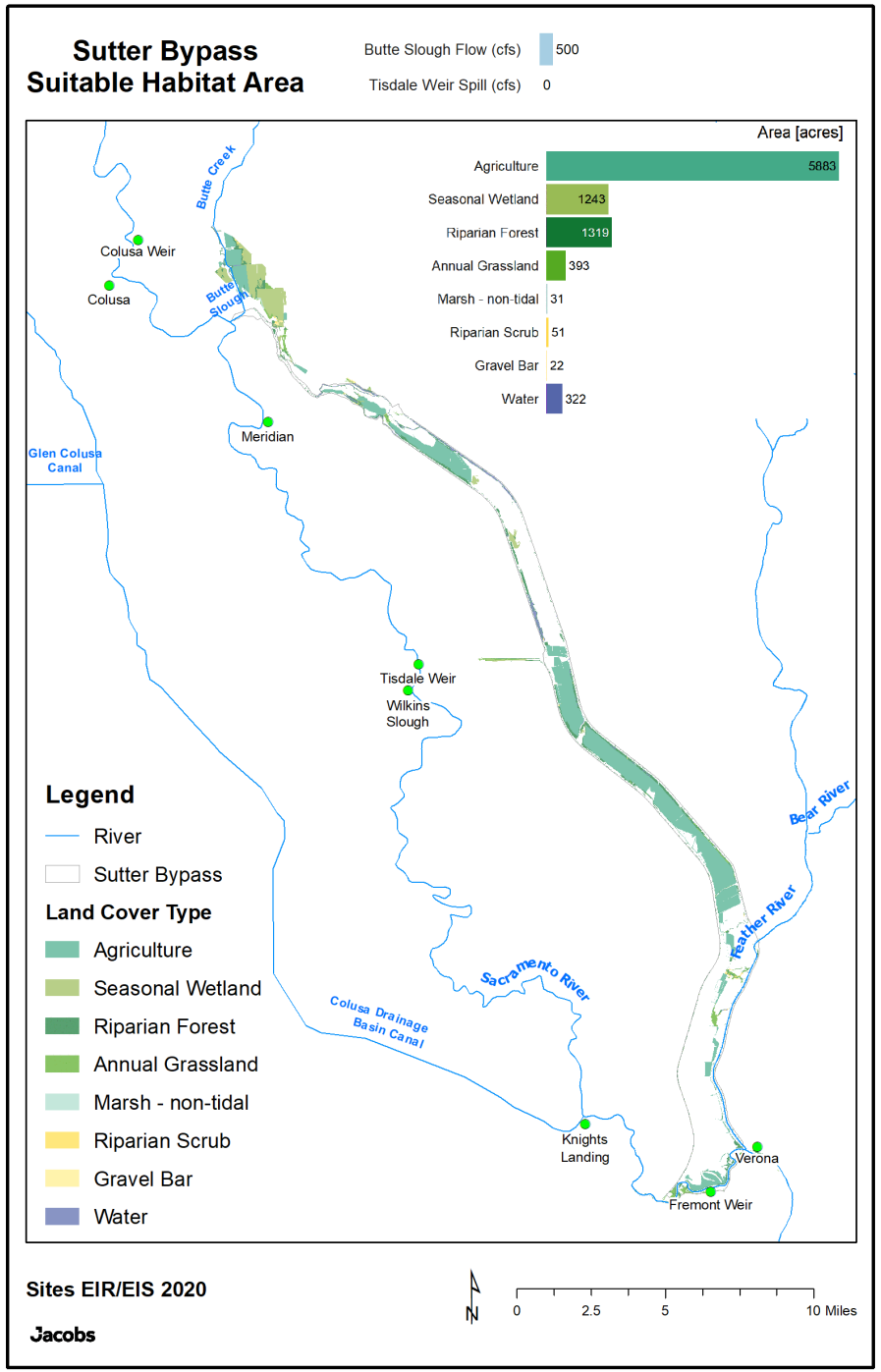
Jacobs

Reach 1: Bend Bridge to Hamilton City
Reach 2: Hamilton City to Colusa
Reach 3: Colusa to Knights Landing

Modeling Methods – Main Channel

- Sensitivity analyses performed for flows in the main channel of the Sacramento River determining flows necessary to satisfy biological criteria (velocity and depth)
- Based on the approach used in WSIP 2017
- HEC-RAS 1D model of the Sacramento River from Bend Bridge to Knights Landing
- Steady-state simulations of flows from 5,000 to 55,900 cfs (40 increments)
- 3 reaches evaluated:
  - Reach 1: Bend Bridge to Hamilton City (including both diversions to Sites Reservoir)
  - Reach 2: Hamilton City to Colusa
  - Reach 3: Colusa to Knight's Landing
- Maps developed showing total acreage of inundation for each land cover type for each scenario

Potential Floodplain Rearing Habitat - Sutter Bypass (Example)



- At lowest flows (Tisdale = 500 cfs, Butte Slough = 1,000 cfs) floodplain habitat occurs in primarily agricultural areas in southern portion of bypass, and some in northern areas

- As flows increase, habitat occurs more in the mid to upper reaches of bypass, and tends to occur in more seasonal wetland and riparian land covers

- Largest amount of usable habitat areas occurs at lower flows through Tisdale Weir, and Butte Slough flows of around 2,000 cfs

Preliminary Observations, Trends, and Opportunities

- Sutter Bypass flows tend to be very flashy, and do not necessarily occur with the frequency (floodplain inundation every 2-3 years) and duration (minimum 7 days) to satisfy salmonid rearing criteria.
- Flows that meet the critical depth and velocity criteria tend to occur on the rising or falling limb of these larger events
- Sites operations may be able to increase the quality and quantity of floodplain habitat areas in the Sutter Bypass by:
  - Targeting diversions / releases that optimize floodplain activation flows in the Bypass
  - Trying to increase the frequency and duration of those optimal flows in the Bypass
- In general, Sacramento River flows of 20,000 – 25,000 cfs at Hamilton City appear to be critical for initiating and optimizing floodplain rearing habitat in the Sutter Bypass

Sites Alternatives Comparisons

	Frequency of All Reaches (Sutter Bypass, Yolo Bypass, & In-Channel) Habitat Area Inundation Events Lasting 8 - 17 Days												
Area Range	No Action	Alt 1A	Alt 1A minus No Action	Percent Change	Alt 1B	Alt 1B minus No Action	Percent Change	Alt 2	Alt 2 minus No Action	Percent Change	Alt 3	Alt 3 minus No Action	Percent Change
0 - 5,000 acres	1	1	0	0%	1	0	0%	1	0	0%	1	0	0%
5,000 - 15,000 acres	35	30	-5	-14%	29	-6	-17%	31	-4	-11%	30	-5	-14%
15,000 - 28,000 acres	44	47	3	7%	47	3	7%	47	3	7%	49	5	11%
>28,000 acres	58	58	0	0%	59	1	2%	58	0	0%	60	2	3%
	Frequency of All Reaches (Sutter Bypass, Yolo Bypass, & In-Channel) Habitat Area Inundation Events Lasting 18 - 24 Days												
Area Range	No Action	Alt 1A	Alt 1A minus No Action	Percent Change	Alt 1B	Alt 1B minus No Action	Percent Change	Alt 2	Alt 2 minus No Action	Percent Change	Alt 3	Alt 3 minus No Action	Percent Change
0 - 5,000 acres	2	2	0	0%	2	0	0%	2	0	0%	2	0	0%
5,000 - 15,000 acres	4	7	3	75%	7	3	75%	6	2	50%	7	3	75%
15,000 - 28,000 acres	2	2	0	0%	2	0	0%	2	0	0%	1	-1	-50%
>28,000 acres	16	17	1	6%	17	1	6%	17	1	6%	19	3	19%
	Frequency of All Reaches (Sutter Bypass, Yolo Bypass, & In-Channel) Habitat Area Inundation Events Lasting More Than 24 Days												
Area Range	No Action	Alt 1A	Alt 1A minus No Action	Percent Change	Alt 1B	Alt 1B minus No Action	Percent Change	Alt 2	Alt 2 minus No Action	Percent Change	Alt 3	Alt 3 minus No Action	Percent Change
0 - 5,000 acres	0	0	0	-	0	0	-	0	0	-	0	0	-
5,000 - 15,000 acres	89	92	3	3%	91	2	2%	93	4	4%	92	3	3%
15,000 - 28,000 acres	2	2	0	0%	2	0	0%	2	0	0%	3	1	50%
>28,000 acres	49	50	1	2%	50	1	2%	50	1	2%	50	1	2%
*Based on total number of events in 82 year simulation period.													

		Mean Daily Inundation Area (Acres) November-June in All Reaches (Sutter Bypass, Yolo Bypass, & In-Channel)					Percent Change from NAA (%)			
Month	Water Year Type	NAA	ALT1A	ALT1B	ALT2	ALT3	ALT1A	ALT1B	ALT2	ALT3
January	Wet	25,793	25,653	25,651	25,674	25,662	-0.5%	-0.6%	-0.5%	-0.5%
	Above Normal	22,690	22,532	22,535	22,533	22,531	-0.7%	-0.7%	-0.7%	-0.7%
	Below Normal	16,786	16,633	16,639	16,638	16,644	-0.9%	-0.9%	-0.9%	-0.8%
	Dry	12,016	11,952	11,944	11,951	11,963	-0.5%	-0.6%	-0.5%	-0.4%
	Critically Dry	11,121	11,071	11,069	11,069	11,070	-0.4%	-0.5%	-0.5%	-0.5%
	All	18,630	18,515	18,514	18,522	18,522	-0.6%	-0.6%	-0.6%	-0.6%
February	Wet	28,995	28,917	28,906	28,924	28,908	-0.3%	-0.3%	-0.2%	-0.3%
	Above Normal	27,639	27,486	27,500	27,490	27,579	-0.6%	-0.5%	-0.5%	-0.2%
	Below Normal	21,620	21,418	21,425	21,415	21,442	-0.9%	-0.9%	-0.9%	-0.8%
	Dry	15,605	15,407	15,426	15,407	15,427	-1.3%	-1.1%	-1.3%	-1.1%
	Critically Dry	11,897	11,861	11,860	11,861	11,861	-0.3%	-0.3%	-0.3%	-0.3%
	All	22,088	21,957	21,961	21,960	21,977	-0.6%	-0.6%	-0.6%	-0.5%
March	Wet	26,155	26,024	26,014	26,024	25,992	-0.5%	-0.5%	-0.5%	-0.6%
	Above Normal	24,558	24,214	24,235	24,216	24,227	-1.4%	-1.3%	-1.4%	-1.3%
	Below Normal	16,617	16,149	16,164	16,153	16,191	-2.8%	-2.7%	-2.8%	-2.6%
	Dry	15,156	14,829	14,826	14,835	14,850	-2.2%	-2.2%	-2.1%	-2.0%
	Critically Dry	12,313	12,244	12,240	12,244	12,245	-0.6%	-0.6%	-0.6%	-0.5%
	All	19,853	19,599	19,600	19,601	19,603	-1.3%	-1.3%	-1.3%	-1.3%
April	Wet	22,554	22,366	22,355	22,378	22,334	-0.8%	-0.9%	-0.8%	-1.0%
	Above Normal	16,940	16,919	16,923	16,919	16,922	-0.1%	-0.1%	-0.1%	-0.1%
	Below Normal	13,015	12,826	12,828	12,826	12,828	-1.5%	-1.4%	-1.5%	-1.4%
	Dry	12,473	12,453	12,453	12,454	12,455	-0.2%	-0.2%	-0.2%	-0.1%
	Critically Dry	11,092	11,093	11,096	11,093	11,094	0.0%	0.0%	0.0%	0.0%
	All	16,213	16,114	16,112	16,119	16,106	-0.6%	-0.6%	-0.6%	-0.7%
May	Wet	14,023	13,863	13,856	13,865	13,818	-1.1%	-1.2%	-1.1%	-1.5%
	Above Normal	12,996	12,984	12,983	12,984	12,983	-0.1%	-0.1%	-0.1%	-0.1%
	Below Normal	11,688	11,683	11,685	11,683	11,689	0.0%	0.0%	0.0%	0.0%
	Dry	11,106	11,090	11,089	11,089	11,099	-0.1%	-0.2%	-0.1%	-0.1%
	Critically Dry	10,170	10,149	10,154	10,151	10,155	-0.2%	-0.2%	-0.2%	-0.1%
	All	12,270	12,210	12,208	12,211	12,199	-0.5%	-0.5%	-0.5%	-0.6%
June	Wet	12,135	12,098	12,096	12,098	12,094	-0.3%	-0.3%	-0.3%	-0.3%
	Above Normal	10,966	10,957	10,954	10,957	10,955	-0.1%	-0.1%	-0.1%	-0.1%
	Below Normal	10,437	10,434	10,434	10,434	10,433	0.0%	0.0%	0.0%	0.0%
	Dry	9,848	9,845	9,847	9,845	9,849	0.0%	0.0%	0.0%	0.0%
	Critically Dry	8,800	8,796	8,797	8,797	8,797	0.0%	0.0%	0.0%	0.0%
	All	10,684	10,669	10,669	10,669	10,668	-0.1%	-0.1%	-0.1%	-0.1%
November	Wet	12,002	12,040	12,074	12,035	12,077	0.3%	0.6%	0.3%	0.6%
	Above Normal	10,622	10,653	10,665	10,434	10,495	0.3%	0.4%	-1.8%	-1.2%
	Below Normal	9,157	9,178	9,183	9,180	9,178	0.2%	0.3%	0.2%	0.2%
	Dry	9,621	9,647	9,646	9,646	9,629	0.3%	0.3%	0.3%	0.1%
	Critically Dry	7,731	7,762	7,775	7,770	7,795	0.4%	0.6%	0.5%	0.8%
	All	10,167	10,197	10,212	10,165	10,187	0.3%	0.4%	0.0%	0.2%
December	Wet	22,332	22,326	22,338	22,334	22,433	0.0%	0.0%	0.0%	0.5%
	Above Normal	13,725	13,641	13,639	13,623	13,597	-0.6%	-0.6%	-0.7%	-0.9%
	Below Normal	11,502	11,464	11,467	11,464	11,472	-0.3%	-0.3%	-0.3%	-0.3%
	Dry	11,616	11,607	11,658	11,611	12,083	-0.1%	0.4%	0.0%	4.0%
	Critically Dry	8,986	8,989	8,989	8,988	8,999	0.0%	0.0%	0.0%	0.1%
	All	14,918	14,896	14,911	14,896	15,031	-0.1%	0.0%	-0.1%	0.8%

*Results are based on 8-day running averages of flows in the Sutter Bypass, Yolo Bypass, and In-Channel.

Findings

- Project alternatives show little to no change in habitat area and the frequencies of inundation events of suitable duration.
- Across study areas, inundation events lasting longer than 24 days appear unaffected by the Project.
- There is more variability for events lasting 8 to 17 or 18 to 24 days. In some instances, Project alternatives demonstrate an increase in habitat area, and more frequent inundation events of suitable duration.
  - Project alternatives' summer and fall ecosystem releases to the Yolo Bypass produce significantly more habitat area than the NAA in those months.
  - On average, in-channel Sacramento flows are higher in the late summer and fall with Project alternatives. Accordingly, habitat area tends to increase in Reaches 1 and 2 during those months.
  - At times, Project alternatives show a reduction in the frequency of habitat inundation events. For example, winter months show a decrease in in-channel average habitat area under Project alternatives due to project diversions.
- Habitat inundation does not increase linearly with flows, especially for the Sutter and Yolo Bypasses.
- Sites provides an opportunity to optimize suitable habitat during high-flow events while storing water for habitat flows during dryer periods.

Questions?