Appendix AB-N, New Melones Stepped Release Plan
Attachment N.2 Stanislaus River Habitat Availability Analysis

N.2.1 Model Overview

Estimation of spawning and rearing habitat availability for salmonids in the Stanislaus River was based on procedures from two different studies. Weighted usable area (WUA) analysis was the principal methodology used to quantify spawning habitat availability for fall-run Chinook and steelhead in the river. WUA was also used to quantify rearing habitat of fry and juvenile fall-run and steelhead in the river, but an additional procedure, based on spatially-explicit hydrodynamic modeling and geographic information system (GIS) tools (hereinafter referred to as "ASH analysis" for "Area of Suitable Habitat") was employed to estimate rearing habitat availability. The three methodologies, consisting of one for evaluating spawning habitat and two for analyzing rearing habitat, are described and discussed below.

N.2.2 Model Development

N.2.2.1 Methods

WUA analysis is a well-established methodology used primarily for quantification of spawning and rearing habitat of fish species in rivers, streams, and floodplains (Bovee et al. 1998). WUA is computed as the surface area of physical habitat available for spawning or rearing, weighted by its suitability. Habitat suitability is determined from field studies of the distributions of redds or rearing juveniles with respect to flow velocities, depths, and substrate or cover in the river or floodplain (Bovee et al. 1998). These data are used in hydraulic and habitat model simulations (e.g., PHABSIM or RIVER2D) to estimate the availability of suitable habitat at a given flow. Habitat mapping is used to extrapolate the site-specific WUA data to a river reach scale. WUA curves showing suitable habitat availability versus flow are generated from the simulations. The WUA curves facilitate evaluating how different flow regimes affect spawning and rearing habitat of important fish species.

The ASH methodology is a recently developed program of procedures designed to achieve most of the same objectives as addressed by the WUA analysis procedures. The ASH procedures were designed in part to address a potential shortcoming of the WUA methodology: uncertainties in extrapolating its intensive, site-specific simulations of habitat conditions to a river reach scale. The ASH procedures include powerful remote sensing and GIS tools, including airborne LiDar, photogrammetry, and boat-mounted SONAR, to expand sampling effort. The downside of this expanded sampling effort is a loss of resolution in the physical data that can feasibly be collected and numerically modelled. The ASH procedure is new and little tested.

The WUA and ASH methodologies have some important similarities. They both rely on information characterizing fish habitat conditions in the river gained from field sampling, information regarding the suitability to fish of different habitat conditions gained from field observations and published studies, and hydrodynamic modeling to quantify the availability of different levels of suitable habitat at different levels of river flow. The primary difference between them is that WUA analysis focuses in detail on short river segments and extrapolates the results to represent the entire river or river reach while the ASH analysis samples the entire 56-mile reach of the Lower Stanislaus River, but with less detail than River2D.

N.2.2.1.1 Spawning Habitat

Spawning habitat availability for this analysis was estimated using the spawning WUA methodology. Modeling assumptions used to derive spawning WUA curves include that the suitability of physical habitat for salmon and steelhead spawning is largely a function of substrate particle size, water depth, and flow velocity. The race- or species-specific suitability of the habitat with respect to these physical habitat variables is determined by cataloguing conditions at active redds and is used to develop habitat suitability criteria (HSC) for each race or species of fish. Hydraulic modeling is then used to estimate the amount of habitat available for different HSC levels at different stream flow, and the results are combined to develop spawning habitat WUA curves and tables (Bovee et al. 1998). The WUA tables are used to look up the amount of spawning WUA available at different flows during the spawning period of the fish.

The LTO Stanislaus River spawning WUA analyses are based on results of field studies conducted by U.S. Fish Wildlife (USFWS) in 1989 (USFWS 1993). The USFWS study developed HSC and used the PHABSIM hydraulic model to simulate habitat suitability conditions for fall-run Chinook and steelhead at different flows. Stanislaus River spawning WUA tables are provided in USFWS (1993).

The USFWS (1993) study was conducted in four segments of the Stanislaus River between Goodwin Dam and the town of Riverbank (Figure N.2-1). The four segments are Two-mile Bar (Goodwin Dam to Knights Ferry reach), Six-mile Bar (upper part of Knights Ferry to Orange Blossom Bridge reach), Honolulu Bar (lower part of Knights Ferry to Orange Blossom Bridge reach), and Valley Oak SRA (Orange Blossom Bridge to Riverbank reach). These segments are about 4 miles, 3.6 miles, 3.8 miles, and 13.7 miles, respectively.

USFWS (1993) provides spawning WUA curves for steelhead and fall-run Chinook salmon spawning habitat in the Stanislaus River for the four segments described above (Figure N.2-2 and Figure N.2-3). The curves for fall-run consistently peak at higher flows than those for steelhead. Steelhead has relatively high spawning WUA in the Valley Oak SRA segment (Figure N.2-2). This segment is about 3.5 times as long as any of the other ones, so total spawning WUA is highest in this segment for both species.

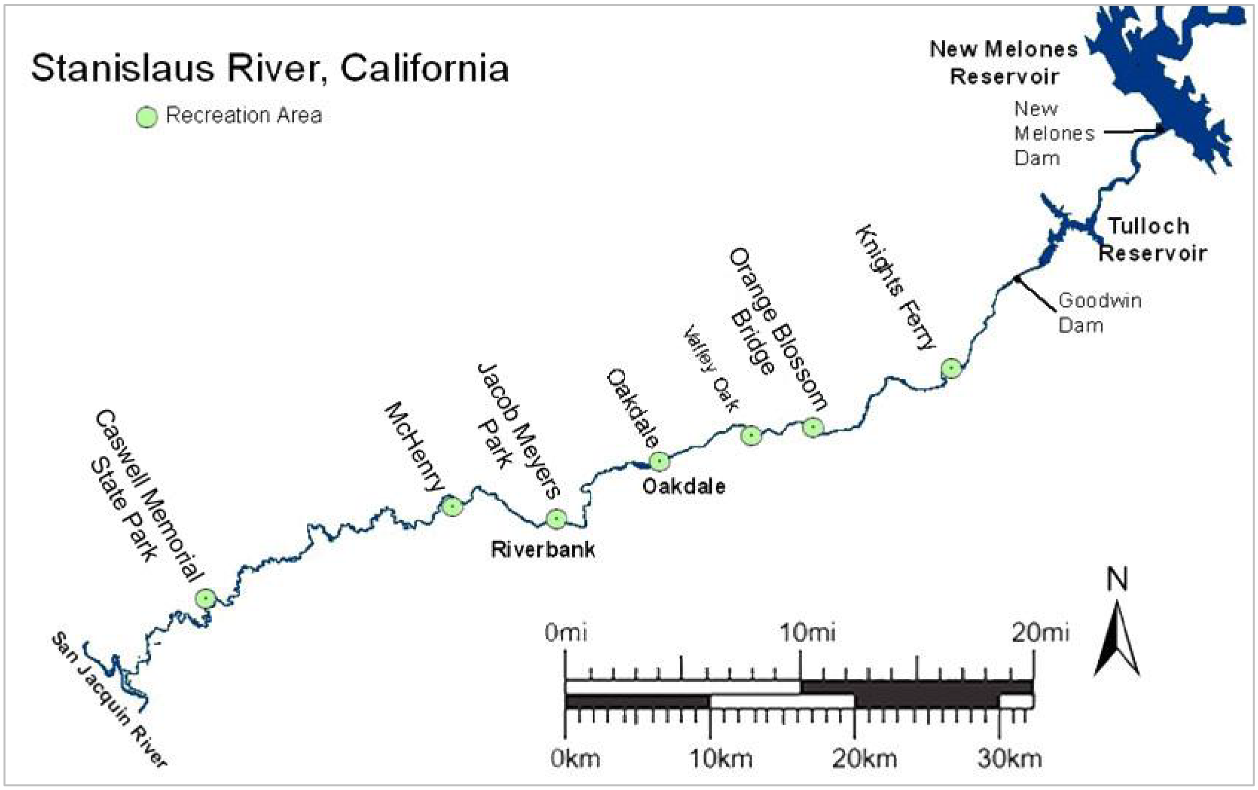

Figure N.2-1. Lower Stanislaus River with Locations Marking Boundaries of Sampling Reaches.

Figure N.2-2. Spawning WUA Curves for Steelhead in Two-Mile Bar, Six-Mile Bar, Honolulu Bar, and Valley Oak SRA Segments of the Stanislaus River.

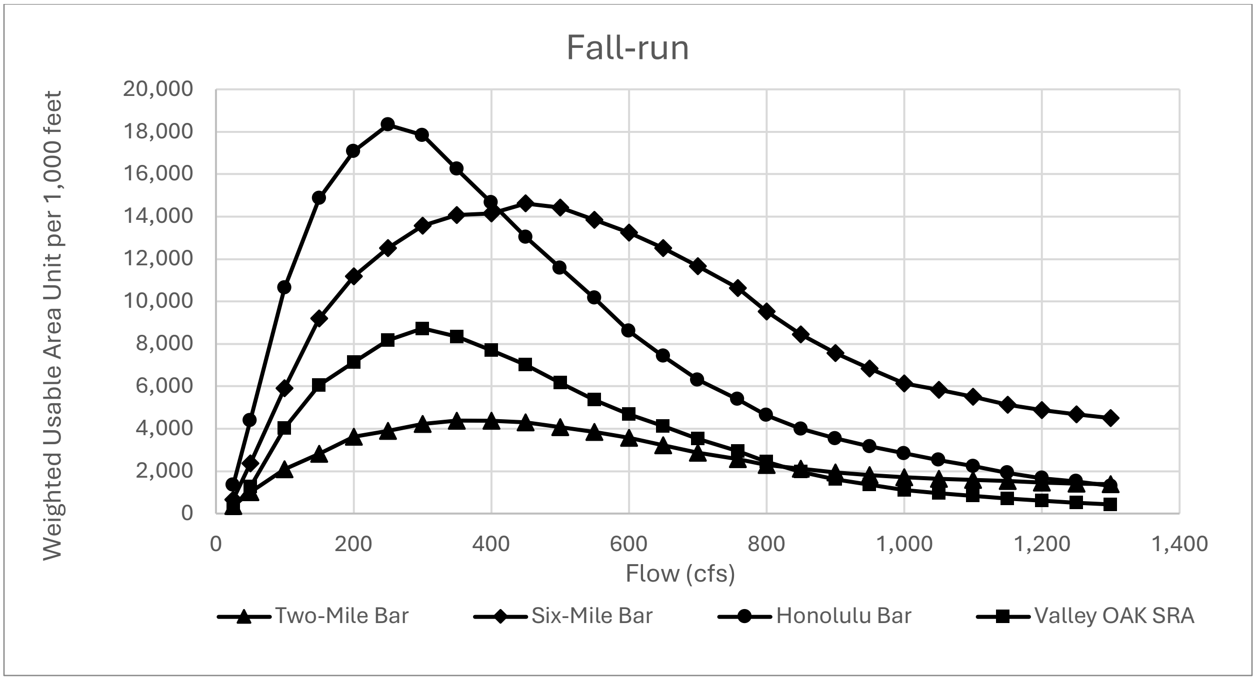

Figure N.2-3. Spawning WUA Curves for Fall–Run Chinook Salmon in Two-Mile Bar, Six-Mile Bar, Honolulu Bar, and Valley Oak SRA Segments of the Stanislaus River.

The spawning WUA tables in USFWS (1993) were used to estimate spawning WUA for the BA and EIS modeled scenarios from CalSim 3 flow data for each month of the 100-year period of record. WUA was estimated for each of the four segments described above using CalSim 3 flow estimates for three different locations: flow at Goodwin Dam was used to compute WUA in the Two-Mile Bar segment, flow at Knights Landing was used to determine WUA at the Six-Mile Bar and Honolulu Bar segments, and flow at Orange Blossom Bridge was used to compute WUA in the Valley Oak SRA segment. The Six-Mile Bar and Honolulu Bar segments are both relatively close to Knights Landing, so flow at Knights Landing is not expected to differ greatly from that within the two segments.

Mean spawning WUA for each water year type and all water year types combined was determined for this analysis for each of the river segments and the principal months of the fall-run and steelhead spawning periods (Table N.2-1). Total fall-run and steelhead spawning WUA was also computed for all months and river segments combined. For fall-run, total WUA was computed by weighting monthly WUA results by monthly spawning occurrence factors (Table N.2-1) and the relative lengths of the river segments (16%, 14%, 15.2% and 54.8% for Two-mile Bar, Six-mile Bar, Honolulu Bar, and Valley Oak SRA, respectively). The relative segment lengths were also used for weighting steelhead total WUA computations, but months were not weighted because information on the steelhead relative spawning occurrence among the spawning period months could not be found.

Table N.2-1. Stanislaus River Spawning Periods for Fall-run Chinook and Steelhead.

Month	Fall-run[1]	Steelhead[2]
October	0.22 (Present)	Absent
November	0.39 (Present)	Absent
December	0.39 (Present)	Present
January	Absent	Present
February	Absent	Present
March	Absent	Present
April	Absent	Present

[1] Fall-run spawning period and weighting factors estimated from Table 1 in USFWS (1993)
[2] Steelhead spawning period estimated from page 214 in SEP (2019)

N.2.2.1.2 Rearing Habitat

As noted in Section N.2.1, *Model Overview*, two different analysis procedures were used for the LTO to estimate habitat availability for rearing fry and juvenile fish, the WUA and ASH methodologies. Both of these methodologies are described in Reclamation (2012).

Modeling assumptions used with WUA to derive rearing WUA curves include that the suitability of physical habitat for salmon and steelhead rearing (fry and juveniles) is largely a function of water depth, flow velocity, adjacent velocity, and the availability of cover. Adjacent velocity is analyzed to account for microhabitats selected by juveniles in quiet water adjacent to more rapid flow, which provides higher rates of prey encounter. Such microhabitats include heads of pools, behind large boulders, riparian vegetation, and riverbanks (Naman et al. 2019). Adjacent velocity is typically measured within 2 feet on either side of the location where the velocity was the highest (USFWS 2011, 2013). The race- or species-specific suitability of the rearing habitat with respect to these physical variables is determined by observing the fish's behaviors and is used to develop HSC for each race or species and life stage. The HSC used for the Stanislaus River WUA study were developed from a WUA study of Chinook salmon and steelhead in the Yuba River (USFWS 2010) because too few observations of fry and juvenile salmonids from the Stanislaus could be obtained during the study for this purpose (Reclamation 2012).

Hydraulic modeling is used to estimate the amount of habitat available for different HSC levels at different river flows, and the results are combined to develop rearing habitat WUA curves and tables (Bovee et al. 1998). For Reclamation's Stanislaus River rearing WUA studies, the primary hydraulic model used was RIVER-2D (Reclamation 2012). The WUA tables are used to look up the amount of rearing WUA available at different flows during the fry and juvenile rearing periods of the fish. Habitat mapping is used to extrapolate the site-specific WUA results to a river reach scale. The Stanislaus River rearing WUA tables are provided in Reclamation (2012). The sampling segments used for the rearing WUA study include the following: Two-Mile Bar reach (4 miles), Knights Landing reach (7.4 miles), Orange Blossom Bridge to Riverbank reach (13.7 miles), and Riverbank to San Joaquin River confluence reach (34.5 miles). The latter reach, which was not included in the spawning WUA study, was added because fall-run and steelhead rearing habitat include all the river downstream of the spawning areas (Reclamation 2012).

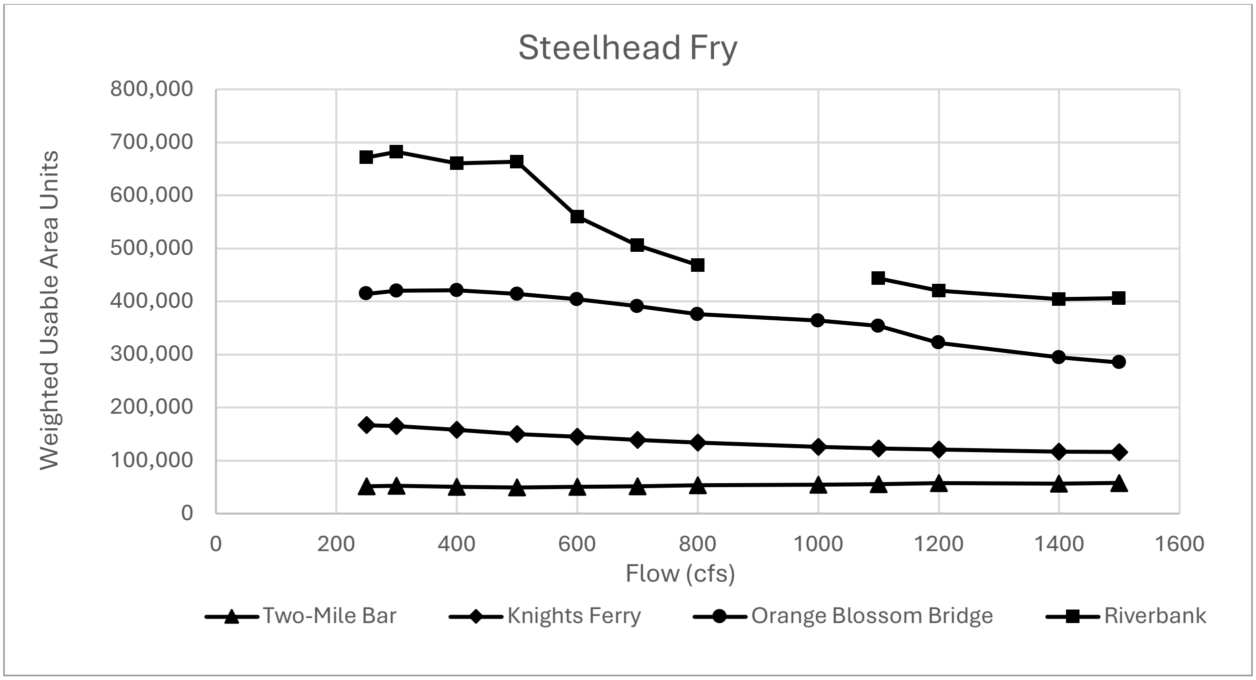

Figure N.2-4. Rearing WUA Curves for Steelhead Fry in Two-Mile Bar, Knights Ferry, Orange Blossom Bridge, and Riverdale Segments of the Stanislaus River.

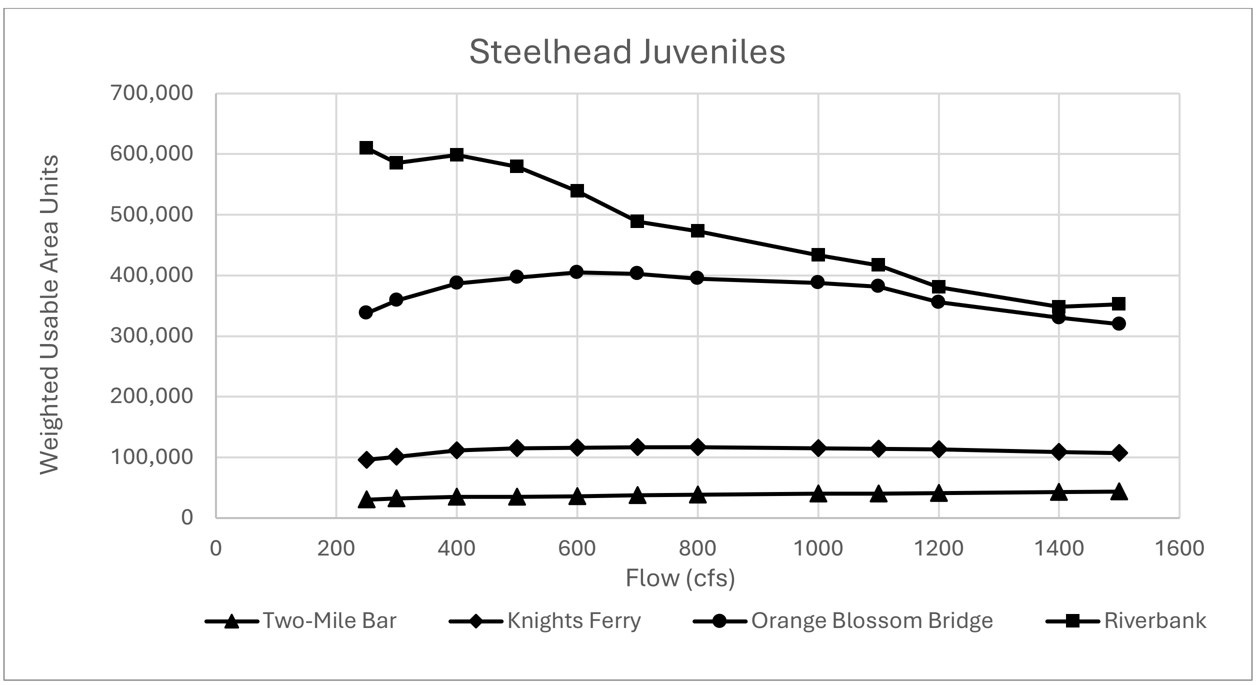

Figure N.2-5. Rearing WUA Curves for Steelhead Juveniles in Two-Mile Bar, Knights Ferry, Orange Blossom Bridge, and Riverdale Segments of the Stanislaus River.

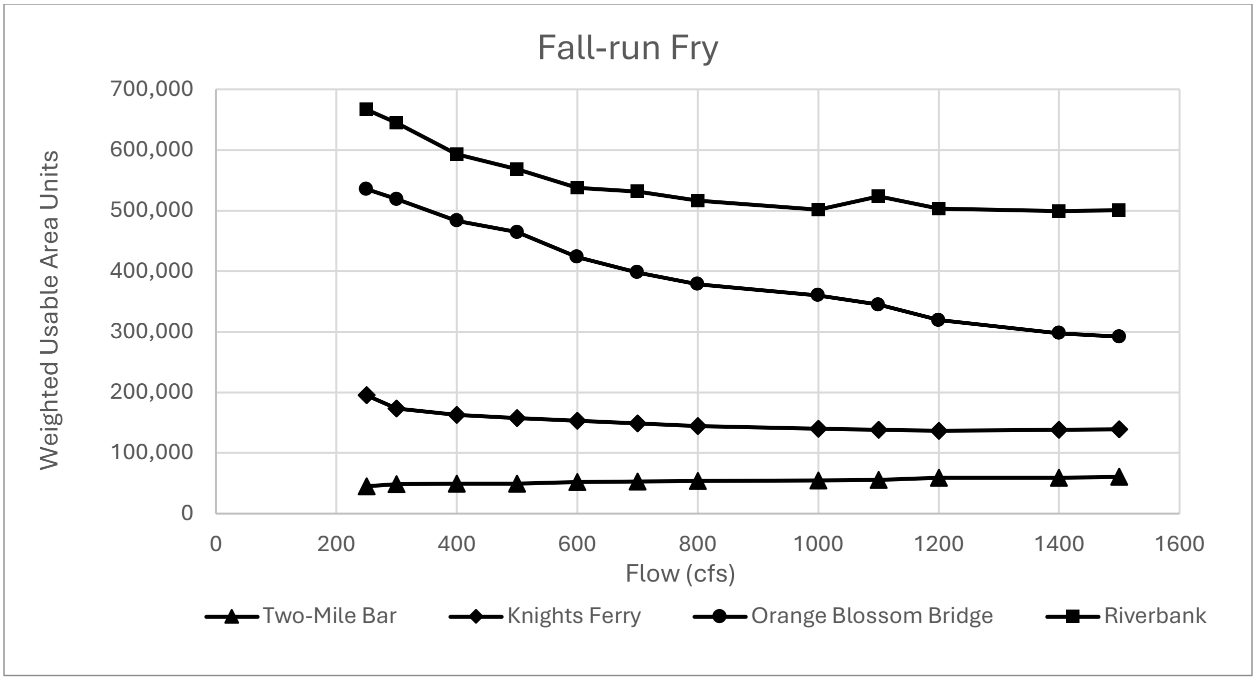

Figure N.2-6. Rearing WUA Curves for Fall-run Fry in Two-Mile Bar, Knights Ferry, Orange Blossom Bridge, and Riverdale Segments of the Stanislaus River.

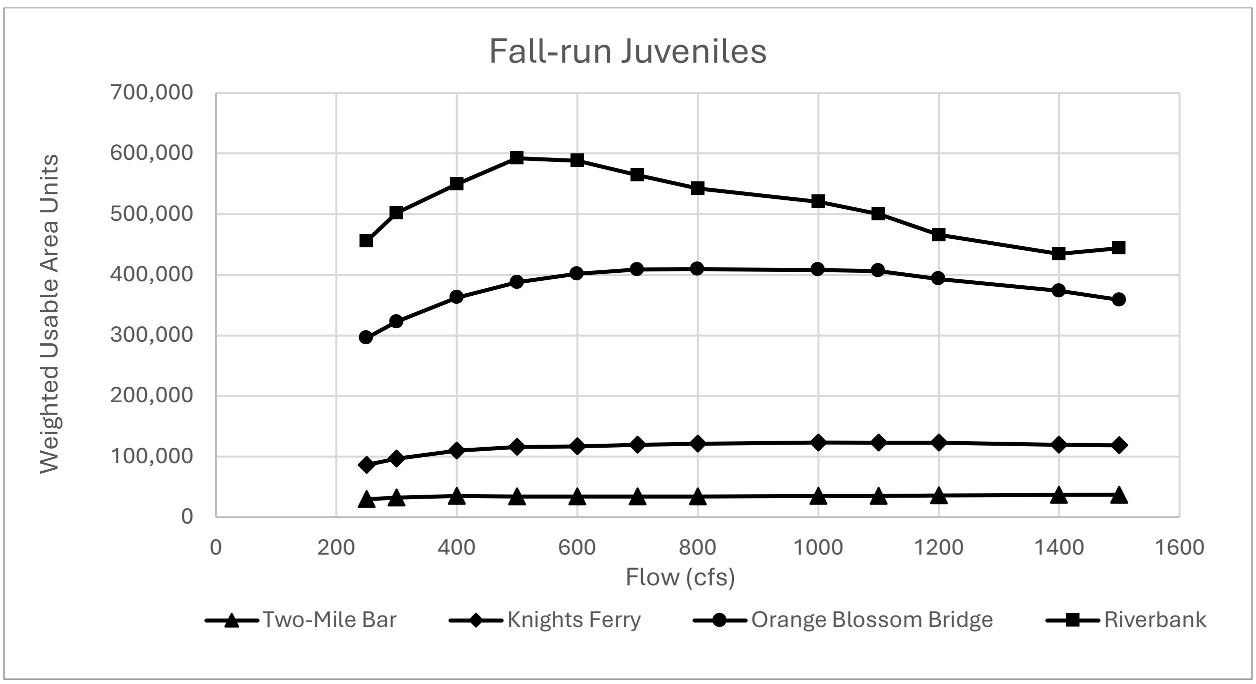

Figure N.2-7. Rearing WUA Curves for Fall-run Fry in Two-Mile Bar, Knights Ferry, Orange Blossom Bridge, and Riverdale Segments of the Stanislaus River.

The ASH methodology for quantifying Stanislaus rearing WUA was developed by Reclamation in consultation with USFWS, NMFS and CDFW (Reclamation 2012). An important motivation for developing the ASH methodology, as noted previously, was to expand the scope of sampling fish habitats to the entire river reach downstream of Knights Landing. The entire river from Knights Landing to the San Joaquin River, a distance of 56 miles, was modeled using the ASH methodology, although the modeling effort divided the river into four segments to make the modeling more manageable (Table N.2-4).

Remote sensing with Airborne LiDar and boat-mounted SONAR was used to measure the topography and bathymetry, respectively, of the river basin and channel. On-site data related to riverbank edge habitat conditions, particularly large woody debris and other structures used as cover by juvenile fish, were also collected to assist in interpreting the remote sensing data. Data from the different sampling efforts were used in a newly developed sedimentation and river hydraulics model, SRH-2D, developed by Reclamation for simulation of habitat conditions in the river at different flows (Lai 2010). These data were included in the SRH-2D modeling together with HSC to develop flow vs. area of suitable habitat tables analogous to the WUA tables. However, because of the large sampling effort required to develop the ASH tables, the tables were developed for only three Stanislaus River flows, 250 cfs, 800 cfs, and 1,500 cfs (Table N.2-2). Note that Segment A (Two-Mile Bar) is absent from the ASH modeling results (Table N.2-2). A severely confined channel with ubiquitous large boulders precluded surveying this segment with the boat-mounted SONAR (Reclamation 2012). For the AHS analyses, the entire river from Knights Landing to the San Joaquin River, a distance of 56 miles, was modeled using the SRH-2D model, although the modeling effort divided the river into four segments to make the modeling more manageable (Table N.2-2).

The HSC used in the ASH analysis were largely the same as those used for the WUA analysis, which were adopted from the Yuba River WUA study (USFWS 2010). However, there are some differences, the most important being how the HSI for cover was defined. For WUA studies, cover is defined in terms of the availability of specific structure, including cobble, boulders, deadwood, vegetation, undercut banks, and others (Reclamation 2012). Sampling effort for such cover is large and would be infeasible at the scale of modeling employed for the ASH study (Reclamation 2012). Therefore, cover for the ASH modeling was defined as “distance to edge”, which refers to the distance in the modeling space from any point in the river to a “dry” point, whether the point is dry due to a shoreline, island, boulder, or any object protruding through the water surface, including woody debris. The remote sensing used in the ASH procedures is capable of automated sampling for such data.

Table N.2-2. Area of Suitable Habitat (ASH) for all life stages in the Stanislaus River using GIS/SRH-2D modeling.

Flow (cfs)	Chinook fry		Chinook juvenile		*O. mykiss* fry		*O. mykiss* juvenile	
	sq ft	% max	sq ft	% max	sq ft	% ma	sq ft	% max
SEGMENT 1-KNIGHTS FERRY RECREATION AREA TO ORANGE BLOSSOM BRIDGE								
250	48,779	50	37,247	29	79,093	49	81,278	48
800	78,304	81	83,332	65	131,395	81	136,492	81
1,500	97,002	100	128,926	100	162,824	100	168,175	100
SEGMENT 2-ORANGE BLOSSOM BRIDGE TO JACOB MEYERS PARK								
250	130,836	85	100,631	47	215,075	92	218,536	93
800	145,011	94	139,387	65	231,380	99	234,959	100
1,500	154,591	100	214,886	100	232,878	100	235,917	100
SEGMENT 3-JACOB MEYERS PARK TO SAN JOAQUIN RIVER								
250	196,083	60	127,986	29	273,512	57	273,711	56
800	319,175	98	267,608	61	462,361	96	462,654	95
1,500	325,590	100	439,620	100	484,000	100	484,624	100
ENTIRE RIVER (SEGMENTS 1-3)								
250	375,698	65	265,864	34	567,680	65	573,525	65
800	542,490	94	490,327	63	825,136	94	834,105	94
1,500	577,183	100	783,432	100	879,702	100	888,716	100

The relationships between flow and habitat availabilities determined using by the WUA versus the ASH methodologies show major differences. Table N.2-3 provides WUA (in square feet) computed for the same three flows (250 cfs, 800 cfs, and 1,500 cfs) that were used for the ASH modeling. These results show that, except in Segment A, the least amount of WUA is generally produced at the highest flow (1,500 cfs). This is particularly true for Segments 2 and 3, which produce the bulk of the rearing habitat. These results are consistent with the rearing WUA curves (Figure N.2-4 though Figure N.2-7). The results from the ASH methodology show (Table N.2-2) a different relationship between flow and habitat availability, with the highest flows consistently producing the maximum amount of habitat.

Table N.2-3. Weighted usable area (WUA) for all life stages in the Stanislaus River using River2D (WUA) modeling.

Flow (cfs)	Chinook fry		Chinook juvenile		*O. mykiss* fry		*O. mykiss* juvenile	
	sq ft	% max	sq ft	% max	sq ft	% ma	sq ft	% max
SEGMENT A-GOODWIN DAM TO TWO-MILE BAR RECREATION AREA								
250	45,012	74.4	29,578	79.7	51,856	89.7	30,204	69.3
800	53,878	89.0	34,349	92.6	53,189	92.0	38,470	88.3
1,500	60,509	100.0	37,113	100.0	57,788	100.0	43,583	100.0
SEGMENT 1-KNIGHTS FERRY TO ORANGE BLOSSOM BRIDGE								
250	195,095	100.0	86,335	71.1	166,554	100.0	96,057	82.2
800	144,327	74.0	121,510	100.0	133,842	80.4	116,817	100.0
1,500	139,210	71.4	118,466	97.5	116,197	69.8	107,219	91.8
SEGMENT 2-ORANGE BLOSSOM BRIDGE TO JACOB MEYERS PARK								
250	535,376	100.0	295,532	72.2	414,417	100.0	337,523	85.5
800	378,407	70.7	409,133	100.0	375,933	90.7	394,966	100.0
1,500	291,861	54.5	358,312	87.6	284,860	68.7	313,957	79.5
SEGMENT 3-JACOB MEYERS PARK TO SAN JOAQUIN RIVER								
250	666,629	100.0	455,738	84.1	671,097	100.0	610,116	100.0
800	516,114	77.4	542,044	100.0	468,044	69.7	473,012	77.5
1,500	500,261	75.0	443,823	81.9	406,112	60.5	352,851	57.8
ENTIRE RIVER (SEGMENT A-TWO-MILE BAR + SEGMENTS 1-3)								
250	1,442,111	100.0	867,183	78.3	1,303,923	100.0	1,073,900	100.0
800	1,092,725	75.8	1,107,037	100.0	1,031,008	79.1	1,023,265	95.3
1,500	991,841	68.8	957,713	86.5	864,957	66.3	817,609	76.1

Reasons for the differences in the flow vs. habitat relationships of the WUA and ASH methodologies are uncertain, but Reclamation (2012) identified several potential explanations. An important potential reason is that the entrenched (steep-banked) morphology of the Lower Stanislaus River channel results in limited increase in wetted area with increased flow over the range of flows studied (250 cfs to 1,500 cfs) and a correspondingly more rapid increase in depth and flow velocity near the channel margins (Reclamation 2012). Increased depth and flow velocity reduce the suitability of the habitat for rearing (Reclamation 2012). The increased depth and flow velocity at channel margins appear to affect the WUA methodologies' determinations of habitat availability more than those of the ASH methodology, and this appears to result from differences in the two methodologies for quantifying suitable cover habitat, as described above. In the WUA methodology, amounts of the different types of cover are estimated from on-site sampling and hydraulic modeling. These amounts are combined with the Suitability Indices (SI) of the cover types (Table 9 in Reclamation 2012) as part of the WUA estimations using the River-2D model. In contrast, suitable cover is quantified in the ASH modeling from remote sensing data, where suitable cover is defined by "distance-to-edge," as defined above. The SIs of different lengths of distance-to-edge were determined from results of previous habitat use surveys (Reclamation 2012). The SRH-2D model quantifies the amounts of different lengths of distance-to-edge in the river, combined with their SIs, as part of the ASH estimation process. The proportions of the more highly suitable WUA cover types may be reduced at higher flows, thereby reducing WUA, while the amount of the river surface within favorable lengths of distance-to-edge may increase with flow, and thereby increase ASH (Reclamation 2012).

Another possible reason for the differences in results between the WUA and ASH methodologies in the relationship between habitat availability and flow is in differences in their scale of sampling and modeling. As previously noted, the WUA methodology intensively analyzes selected, relatively short river segments, then uses results of large-scale habitat mapping to extrapolate the results from the intensive analyses to the entire river reach. If the shorter, intensively analyzed segments do not adequately represent the habitats included in the habitat mapping, the extrapolation of results to the entire river reach could result in biased estimates. In contrast, the ASH analysis samples and models the entire 56-mile reach of the river downstream of Knight's Landing, but with less detail than River2D.

The following table from Reclamation (2012) provides a comparison of the similarities and differences between the WUA and ASH methodologies for the Stanislaus River (Table N.2-4). It should be noted that some of the remote sensing tools used in the ASH methodology were used to expand the WUA sampling, including LiDar and SONAR for the bed topographic mapping.

Table N.2-4. Comparison of Methods Used with the WUA (River2D) and GIS Spatially Explicit (ASH) Models on the Stanislaus River.

Method	River2D	GIS spatially explicit
Two-dimensional Hydraulic model	River2D	SRH-2D
Segments/study sites modeled	1) Two-mile Bar representing 4 mi of river below Goodwin Dam (Segment A)	1) Knights Ferry to Orange Blossom Bridge (Segment 1)
	2) Knights Ferry (Segment 1) to Orange Blossom Bridge	2) Orange Blossom Bridge to Riverbank (Segment 2)
	3) Orange Blossom Bridge to Riverbank, CA (Segment 2)	3) Riverbank to Ripon (Segment 3)
	4) Jacob Meyers to confluence with San Joaquin River (Segment 3)	4) Ripon to confluence with San Joaquin River (Segment 4)
	Total length modeled – 2.0 mi	Total length modeled – 56 mi
Discharge range modeled	Discharges ranging from 250 cfs to 1,500 cfs	Same
Habitat mapping	Approximately 10 miles	Mapped habitat for the entire river using the model
Bed topography	• Total station (x, y ,z coordinates) • Light Detection And Ranging (LiDAR) • Sound Navigation And Ranging (SONAR) • River2D R2D_BED utility program	• Arc GIS • LiDAR and photogrammetry SONAR-inverse distance weighted (IDW) interpolation • Surface-water Modeling System (SMS)
Water surface elevations (WSELs)	Total station – PHABSIM, 1d model	RTK-GPS survey equipment
Velocity validation	None	ADCP RTK-GPS – Arc GIS
Species/life stages	• Fall run Chinook salmon fry • Fall run Chinook salmon juvenile • *O.mykiss* fry • *O.mykiss* juvenile	Same
Microhabitat	Mean column velocity (m/sec)	Mean column velocity (m/sec)
modeled	Depth (m)	Depth (m)
	Cover	Distance to edge (m)
	Adjacent velocity (m/sec)	Velocity shear (s^{-1})
Composite suitability index (CSI) equation	$CSI = SI_{vel} \times SI_{dep} \times SI_{cov} \times SI_{adj\ vel}$, where • *SI* = suitability index, • *vel* = velocity, • *dep* = depth, • *cov* = cover,	$CSI = SI_{vel} \times SI_{dep} \times SI_{d2e} \times SI_{she}$, where • *SI* = suitability index, • *vel* = velocity, • *dep* = depth, • *d2e* = distance to edge,

It is interesting to note that a third independent study of the effect of flow on rearing habitat in the Stanislaus River found results that are intermediate between those of the WUA and ASH methodologies, showing neither reduction nor increase in habitat with flow (FISHBIO and Normandeau Associates 2012). The study was limited to Chinook salmon fry. This study was primarily based on field observations of rearing habitats and fry Chinook habitat use at different flows in a 14-mile reach of the river. The study included no hydrodynamic modeling. Figure N.2-8 shows the relationship between Chinook fry habitat availability and flow as determined by the study.

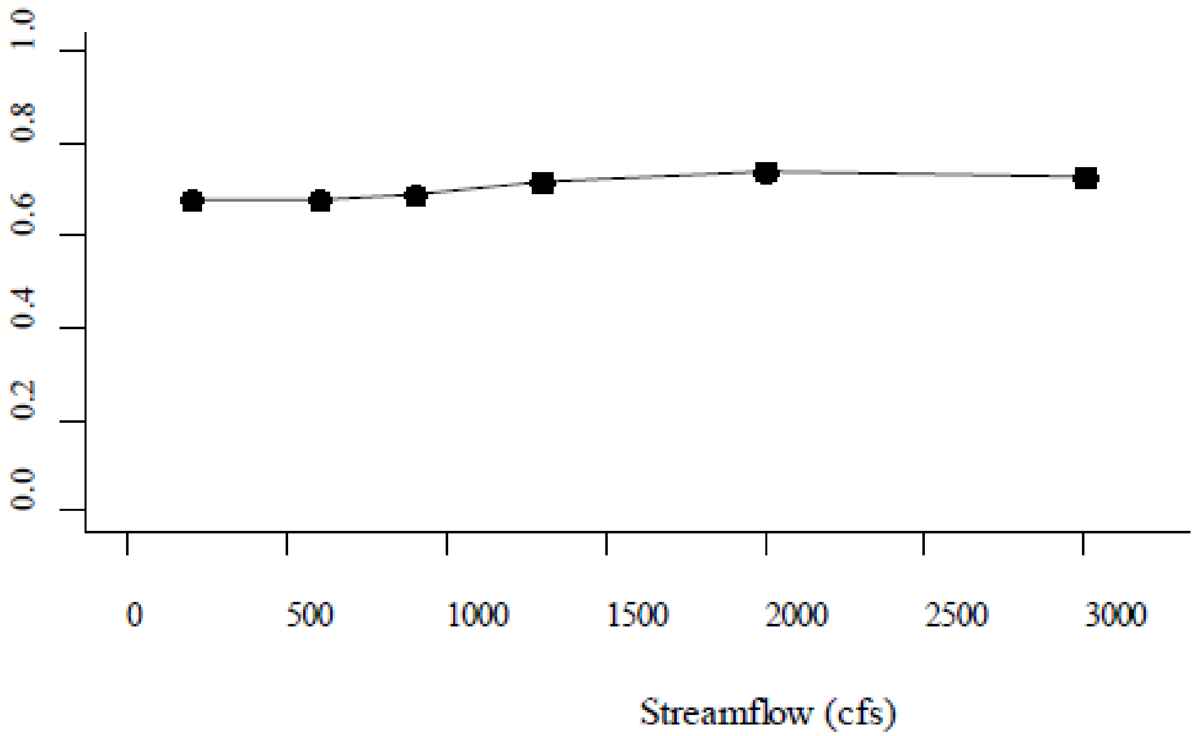

Figure N.2-8. Overall Habitat Score (Y-axis) for Chinook Fry in the Stanislaus River at Various Discharge Levels.

The rearing WUA and ASH tables developed using the WUA (Reclamation 2012) and ASH (Table N.2-2) methodologies were used to estimate rearing habitat availability for the BA and EIS modeled scenarios from CalSim 3 flow data for each month of the 100-year period of record. Mean total WUA was estimated for each of the four segments described above using CalSim 3 flow estimates for four different locations: flow at Goodwin Dam was used to compute WUA in the Two-Mile Bar segment, flow at Knights Landing was used to determine WUA in the Knights Ferry segment, and flow at Orange Blossom Bridge was used to compute WUA in both the Orange Blossom Bridge and the Riverbank segments. For the ASH methodology, mean total ASH was estimated for the entire river using weighted mean CalSim 3 flow estimates for Knights Landing and Orange Blossom Bridge combined. The coefficients used to weight the means are the proportions of 56-mile length of the river between Knight Landing and the confluence represented by each segment; 0.13 for the Knights Landing reach and 0.87 for the combined Orange Blossom and Riverbank reaches.

The WUA and ASH estimates were computed for the principal months of rearing in the lower Stanislaus River, as given in Table N.2-5. For fall-run fry, each month was weighted by relative occurrence of fry in that month. For the other species and life stages, information on occurrence was not sufficiently detailed for such weightings.

Table N.2-5. Stanislaus River Rearing Periods for Fall-run Chinook and Steelhead.

Month	Fall-run Fry[1]	Fall-run Juveniles[2]	Steelhead Fry[2]	Steelhead Juveniles[2]
January	0.2 (Present)	Absent	Absent	Present
February	0.4 (Present)	Present	Absent	Present
March	0.4 (Present)	Present	Absent	Present
April	0.2 (Present)	Present	Present	Present
May	Absent	Present	Present	Present
June	Absent	Present	Present	Present
July	Absent	Absent	Present	Present
August	Absent	Absent	Present	Present
September	Absent	Absent	Present	Present
October	Absent	Absent	Absent	Present
November	Absent	Absent	Absent	Present
December	Absent	Absent	Absent	Present

[1] Fall-run fry rearing periods and weighting factors estimated from Table 1 in USFWS (1993)
[2] Rearing periods estimated from Table 8 and Figure 8 in SEP (2019)

N.2.2.2 Assumptions / Uncertainty

This section includes two subsections. The first subsection provides a list of some important uncertainties and assumptions of the WUA analyses used for this effects analysis. The second subsection provides a more general discussion of the validity of WUA analysis, responding to concerns that have been raised in the scientific literature.

N.2.2.2.1 Important Uncertainties and Assumptions of the WUA Analyses Conducted for this Analysis

1. The CalSim 3 operations model used to estimate spawning and rearing WUA under the scenarios and the alternatives uses a monthly timestep. Therefore, the WUA results should be treated as monthly averages. Using monthly averages to compare spawning and rearing WUA results is suitable for showing differences in effects of the different flow regimes under scenarios and alternatives conditions. Monthly average WUA results faithfully represent the average conditions affecting the fish.

2. The suitability of physical habitat for salmon and steelhead spawning is largely a function of substrate particle size, water depth, and flow velocity. Other unmeasured factors (e.g., flow vortices, competition, water quality, etc.) could influence habitat suitability, contributing to uncertainty in the results.

3. The suitability of physical habitat for salmon and steelhead fry and juvenile rearing is largely a function of availability of cover, water depth, and flow velocity. Other unmeasured factors (e.g., flow vortices, complex feeding behaviors, competition, water quality, food supply, etc.) could influence habitat suitability, contributing to uncertainty in the results.
4. The output of the WUA analysis, is an index of habitat suitability, not an absolute measure of habitat surface area. In the literature, including in the USFWS reports on which this analysis is based (USFWS 2007, 2011a, 2011b, 2013a), Weighted Usable Area may be expressed as square feet, square meters, or acres for a given linear distance of stream, which is misleading and can result in unsupported conclusions (Payne 2003; Railsback 2016; Reiser and Hilgert 2018).
5. Fixed spawning periods were used in this analysis for determining effects of changes in flow on spawning WUA (Table N.2-1). These periods are provided by USFWS (1993) and NMFS (2019), which have collected and reviewed data on spawning of salmonids in the Stanislaus River over many years. They are expected to represent the primary spawning periods of the fish. However, the timing of spawning by salmon and steelhead may vary somewhat among years depending on flows (Quinn 2005). The timing of spawning may be directly affected by flow volume in spawning habitats or indirectly affected via flow effects on upstream migration timing or water temperatures (Sullivan and Hileman 2019; Jennings and Hendrix 2020). The use of fixed spawning periods for this analysis does not account for these potential variations either in flow from year to year nor for differences in flow regimes between the alternative scenarios, which potentially increases uncertainty in the results. However, variations from the primary spawning periods are likely to be small, because spawn timing is a conservative, genetically controlled trait in anadromous fish (Quinn 2005).
6. Habitats of the short, intensively sampled river segments accurately represent habitats of the larger river segments used to extrapolate WUA results to the entire lower Stanislaus River.
7. WUA analyses assume that the channel characteristics of the river, such as proportions of mesohabitat types, during the time of field data collection by USFWS (1989) and Reclamation (2012) have remained in dynamic equilibrium to the present time and will continue to do so through the life of the Project. If the channel characteristics substantially changed, the shape of the WUA curves might no longer be applicable.

N.2.2.2.2 Discussion Regarding Validity of Weighted Usable Area Analysis

WUA analysis is among the most widely used and recognized analytical tools for assessing effects of flow on fish populations (Reiser and Hilgert 2018). Procedures for quantifying WUA were developed and standardized by USFWS in the 1970s and they have since been widely adopted by researchers (e.g., Bourgeois et al. 1996; Beecher et al. 2010; Railsback 2016; Naman et al. 2020). However, WUA analysis has received some criticism from instream flow analysis practitioners, especially in recent years. Therefore, it is important to understand and evaluate the criticisms of WUA analysis and consider any potential limitations for assessing flow-related effects.

Two frequent criticisms of the WUA analysis that are most potentially relevant with regard to the results and conclusions of the analysis are: (1) WUA analysis fails to directly evaluate many factors that are known to be important to fish population production, including water quality (especially temperature), predation, competition, and food supply Beecher et al. 2010; Railsback 2016; Naman et al. 2019, 2020). Effects of flows on critical processes such channel maintenance, floodplain inundation, and riparian regeneration are also beyond the scope of WUA analyses (Poff et al. 1997; Petts 2009), and (2) the models employed to develop the WUA curves (especially PHABSIM) are antiquated, the field observations and measurements used to run the models are not sufficiently fine-grained to capture important highly localized factors, and the models do not adequately capture many dynamic properties of fish habitat use (Railsback 2016; Reiser and Hilgert 2018).

Regarding the first criticism, PHABSIM and the WUA curves they produce were never meant to address all factors affecting fish populations. As noted in a recent paper rebutting many of the criticisms of PHABSIM (Stalnaker et al. 2017): "PHABSIM is a component of instream flow incremental methodology (IFIM), which is a multifaceted decision support system that looks at riverine ecology for the purpose of making water management decisions." The IFIM uses a suite of evaluation tools (including PHABSIM) and investigates water quality factors and other factors that affect fish in addition to the hydraulic-related habitat conditions analyzed using PHABSIM or related hydraulic habitat models such as RIVER-2D (Beecher 2017). Analysis methods other than PHABSIM are used to evaluate the other factors, which may or may not be affected by flow. These methods typically include evaluation tools for assessing effects on water temperatures, redd dewatering, adult migration passage, emigrating juvenile salmonid survival, water diversion entrainment, and other factors. Conclusions regarding effects of the Project on a species are based on evaluations of the results for all the factors analyzed.

The second criticism is more specific to the modeling tools used for WUA analyses. Many of the limitations of PHABSIM cited by critics are acknowledged by its defenders (Beecher 2017; Stalnaker et al. 2017; Reiser and Hilgert 2018). Some of the cited shortcomings are common to any model that attempts to simulate complex ecological systems. Others reflect that PHABSIM is antiquated; newer, more powerful procedures have been incorporated into newer models. In fact, many studies have replaced or combined PHABSIM with more powerful tools in recent years, including the RIVER2D hydraulic and habitat model, which was the principal hydraulic habitat model used in the rearing WUA analyses (Reclamation 2012) to develop the Stanislaus rearing WUA curves used in this analysis. The habitat variables included in the hydraulic/habitat modeling have also been expanded and improved (Li et al. 2019). For instance, improvements have been made in the flow velocity data used to represent the full range of flow velocity conditions affecting drift-feeding juvenile salmonids (Naman et al. 2019). Some of these improvements were incorporated in the Stanislaus rearing WUA analyses (Reclamation 2012)). In addition, improvements have been developed to include a broader range of factors in the modeling, including some of those mentioned in the previous paragraph. One of these includes modeling of bioenergetic factors (Naman et al. 2020). Such methods are promising, but they are not currently available for use in analyzing flow effects on fish populations in the Stanislaus River.

Some shortcomings of WUA analysis are more difficult to remedy. For instance, competition within a cohort of juvenile salmonids may affect habitat use such that dominant fish exclude sub-dominants from optimal habitat locations, resulting in the highest densities of fish occupying sub-optimal habitat (Beecher et al. 2010; Beecher 2017). Some such biases are inevitable in any effort to model fish populations, but improvements in sampling and modeling techniques can be expected to lead to more accurate models in the future. PHABSIM and similar models, despite their shortcomings, continue to be among the most used and useful analytical tools for assessing instream-flow-related issues (Reiser and Hilgert 2018).

N.2.2.3 Code and Data Repository

Data for this analysis is available from Reclamation upon request.

N.2.3 Results

The following results provide the estimates of spawning and rearing WUA for steelhead and fall-run Chinook salmon. For each race and species, the spawning and rearing WUA results are provided separately, with tables and figures for the BA and EIS modeled scenarios included in each section.

N.2.3.1 Steelhead

N.2.3.1.1 Spawning Weighted Usable Area

Table N.2-6 and Table N.2-7 provide the spawning WUA results for steelhead under the BA modeled scenarios and EIS modeled scenarios, respectively. The results are the mean total WUAs for the months of spawning for all years analyzed, weighted by the relative lengths of the river segments sampled. The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table N.2-7).

The results for both the BA and EIS modeled scenarios show largely consistent variation in mean spawning WUA with water year type among the NAA and the BA and EIS modeled scenarios for alternatives, with mean WUA steadily decreasing from critical water years to wet years (Table N.2-6 and Table N.2-7). EXP 1 and EXP3 show similar patterns of variation with respect to water year type, but their WUA values are consistently lower than those of the NAA and BA and EIS modeled scenarios. The reductions in WUA with wetter water years types reflects the steelhead spawning WUA curves (Figure N.2-2), which show reduced WUA with increased flow, except at the lowest flows (less than about 200 cfs). For the EIS modeled scenarios, most of the scenarios have consistently lower steelhead mean spawning WUA values than the NAA (Table N.2-7). Only Alt 3 shows an increase, 0.6% higher spawning WUA in above normal water years. Alt 1 and Alt 3 show particularly large reductions from the NAA, with a maximum reduction of 21.5% dry water years for both EIS modeled scenarios (Table N.2-7). The other scenarios have lower mean spawning WUA than the NAA under all water year types, with reduction ranging from 1.2% to 6.6% (Table N.2-7).

Table N.2-6. Expected Mean Total WUA for Steelhead Spawning in the Stanislaus River for the for EXP1, EXP3, the NAA, and Four Phases of Alternative 2.

WYT	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	114,617	205,894	364,959	360,409	360,530	360,125	360,239
AN	111,203	236,196	429,481	414,114	414,070	414,070	414,068
BN	135,509	325,043	460,146	429,708	448,814	448,814	448,811
Dry	136,709	449,406	673,152	637,220	645,747	645,691	645,709
Critical	372,516	641,211	722,916	701,832	701,622	700,988	701,294
All	208,251	417,082	563,238	542,370	546,636	546,322	546,453

Table N.2-7. Expected Mean Total WUA for Steelhead Spawning in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	364,959	314,401	360,409	360,530	360,125	360,239	277,294	360,466
AN	429,481	376,630	414,114	414,070	414,070	414,068	431,903	414,117
BN	460,146	432,697	429,708	448,814	448,814	448,811	375,049	429,680
Dry	673,152	528,577	637,220	645,747	645,691	645,709	528,713	637,263
Critical	722,916	609,693	701,832	701,622	700,988	701,294	715,068	701,836
All	563,238	477,985	542,370	546,636	546,322	546,453	504,328	542,388
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	364,959	-13.85	-1.25	-1.21	-1.32	-1.29	-24.02	-1.23
AN	429,481	-12.31	-3.58	-3.59	-3.59	-3.59	0.56	-3.58
BN	460,146	-5.97	-6.61	-2.46	-2.46	-2.46	-18.49	-6.62
Dry	673,152	-21.48	-5.34	-4.07	-4.08	-4.08	-21.46	-5.33
Critical	722,916	-15.66	-2.92	-2.95	-3.03	-2.99	-1.09	-2.92
All	563,238	-15.14	-3.71	-2.95	-3.00	-2.98	-10.46	-3.70

Figure N.2-9 and Figure N.2-10 show the full variation in estimated spawning WUA for steelhead under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the spawning WUA curves from which they are estimated (Figure N.2-2). Under the modeled scenarios, the four phases of Alt2 have similar median values for December, January, and March, are slightly lower for February, and much lower in April (Figure N.2-9 and Figure N.2-10). EXP1 and EXP3 are consistently lower than NAA and the four phases of Alt2, except in April when the NAA median is lower. The median values for all alternatives are much lower in April than in the other months (Figure N.2-9 and Figure N.2-10). This difference is attributable to relatively high flows in drier water year types during April and the low flows at which steelhead spawning WUA peaks in the Stanislaus River (Figure N.2-2).

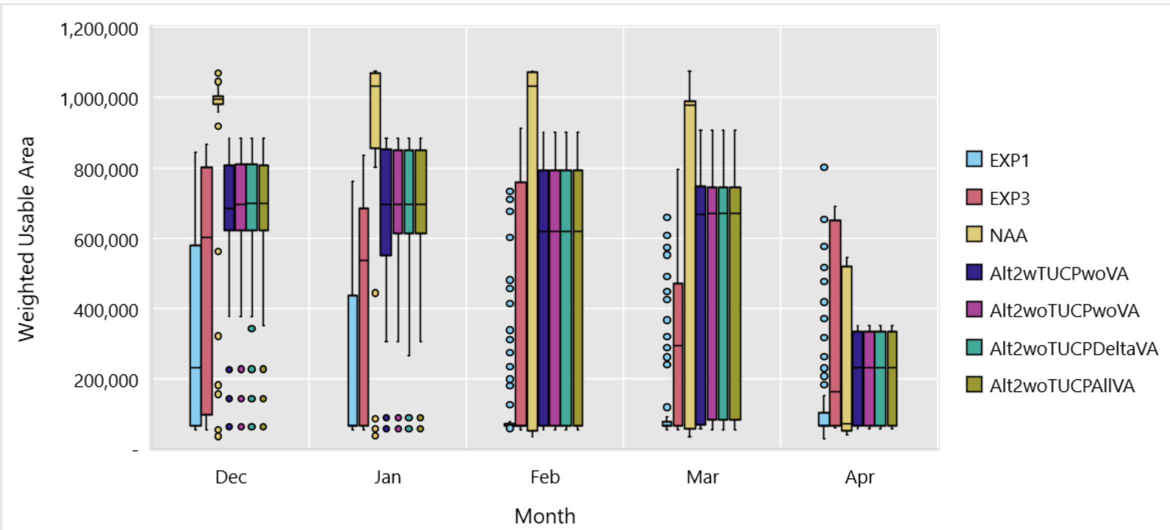

Figure N.2-9. Expected Mean WUA for Steelhead Spawning in the Stanislaus River Downstream of Goodwin Dam for EXP1, EXP3, the NAA, and Four Phases of Alternative 2 by Month

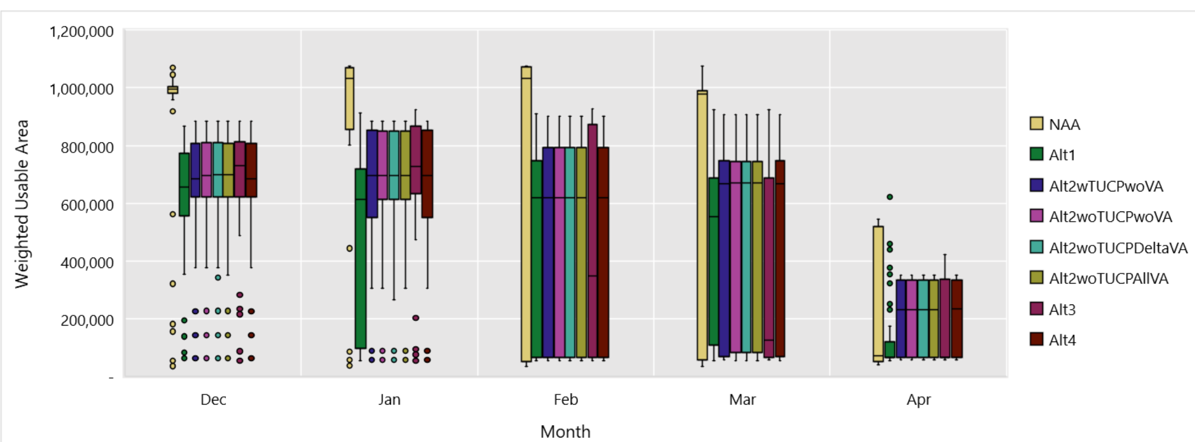

Figure N.2-10. Expected Mean WUA for Steelhead Spawning in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

N.2.3.1.2 Rearing Weighted Usable Area (WUA)

Table N.2-8 through Table N.2-11 provide the rearing WUA results for steelhead fry and juveniles under the BA modeled scenarios and EIS modeled scenarios. The results are the mean WUAs for the months of rearing summed over the four river segments for all years analyzed. The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table N.2-9 and Table N.2-11).

Fry Rearing

The results for both the BA and EIS modeled scenarios generally show little difference in mean fry rearing WUA between critical and dry water year types for the BA and EIS modeled scenarios and gradual reductions in wetter years (Table N.2-8 and Table N.2-9). This pattern of variation reflects the steelhead fry WUA curves (Figure N.2-4), which show reduced WUA with increased flow, especially in Orange Blossom Bridge and Riverbank, which are the longest segments. For the EIS modeled scenarios, all differences in steelhead mean fry rearing WUA between the scenarios and the NAA are less than 5%, with the largest differences 3.4% reductions for dry water year types under Alternatives 1 and Alternative 3 and the largest increases 3.2% for dry water years under the four phases of Alternative 2 and Alternative 4 (Table N.2-8). All other differences are less than 2% (Table N.2-7).

Table N.2-8. Expected Mean Total WUA for Steelhead Fry Rearing in the Stanislaus River for EXP1, EXP3, the NAA, and Four Phases of Alternative 2.

WYT	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	832,860	1,090,243	1,420,725	1,429,541	1,429,666	1,429,667	1,429,708
AN	930,233	1,033,969	1,574,271	1,583,275	1,583,160	1,583,163	1,583,149
BN	919,251	1,039,316	1,584,416	1,612,695	1,613,457	1,613,456	1,613,454
Dry	1,223,458	1,214,870	1,690,665	1,745,318	1,745,327	1,745,315	1,745,329
Critical	977,529	1,250,027	1,759,440	1,744,461	1,736,667	1,736,667	1,736,661
All	973,092	1,151,364	1,624,757	1,636,217	1,633,697	1,633,695	1,633,702

Table N.2-9. Expected Mean Total WUA for Steelhead Fry Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	1,420,725	1,448,656	1,429,541	1,429,666	1,429,667	1,429,708	1,435,237	1,429,485
AN	1,574,271	1,565,718	1,583,275	1,583,160	1,583,163	1,583,149	1,558,843	1,583,275
BN	1,584,416	1,604,171	1,612,695	1,613,457	1,613,456	1,613,454	1,576,288	1,612,705
Dry	1,690,665	1,633,135	1,745,318	1,745,327	1,745,315	1,745,329	1,633,632	1,745,355
Critical	1,759,440	1,729,829	1,744,461	1,736,667	1,736,667	1,736,661	1,747,293	1,744,510
All	1,624,757	1,612,991	1,636,217	1,633,697	1,633,695	1,633,702	1,611,053	1,636,229

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	1,420,725	1.97	0.62	0.63	0.63	0.63	1.02	0.62
AN	1,574,271	-0.54	0.57	0.56	0.56	0.56	-0.98	0.57
BN	1,584,416	1.25	1.78	1.83	1.83	1.83	-0.51	1.79
Dry	1,690,665	-3.40	3.23	3.23	3.23	3.23	-3.37	3.23
Critical	1,759,440	-1.68	-0.85	-1.29	-1.29	-1.29	-0.69	-0.85
All	1,624,757	-0.72	0.71	0.55	0.55	0.55	-0.84	0.71

Figure N.2-11 and Figure N.2-12 show the full variation in estimated fry rearing WUA for steelhead under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the fry rearing WUA curves from which they are estimated (Figure N.2-4). Under the BA modeled scenarios, the four phases of Alternative 2 have similar median values in all months of the fry rearing period and the medians are consistently higher than those of EXP1 and EXP3 (Figure N.2-11). The NAA median values are similar to the four phases of Alternative 2 for most of the fry rearing months, except for April, when the NAA has a lower median (Figure N.2-11 and Figure N.2-12). The four phases of Alternative 2 and Alternative 4 have the highest median WUA values compared to the other scenarios in all four months (Figure N.2-12).

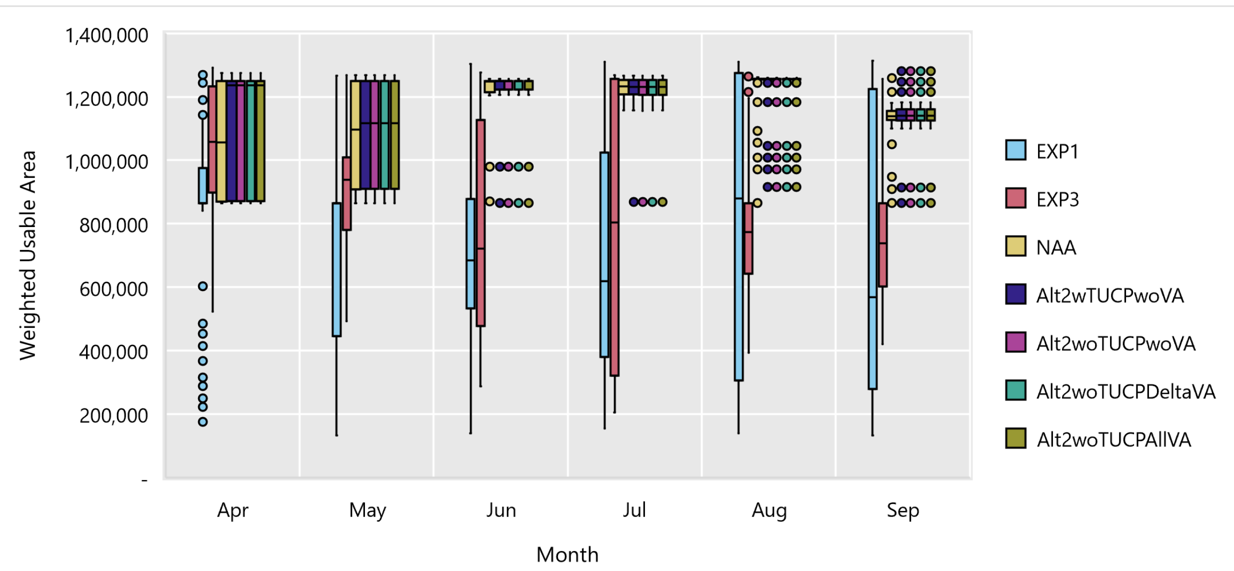

Figure N.2-11. Expected Total WUA for Steelhead Fry Rearing in the Stanislaus River Downstream of Goodwin Dam for EXP1, EXP3, the NAA, and Four Phases of Alternative 2 by Month

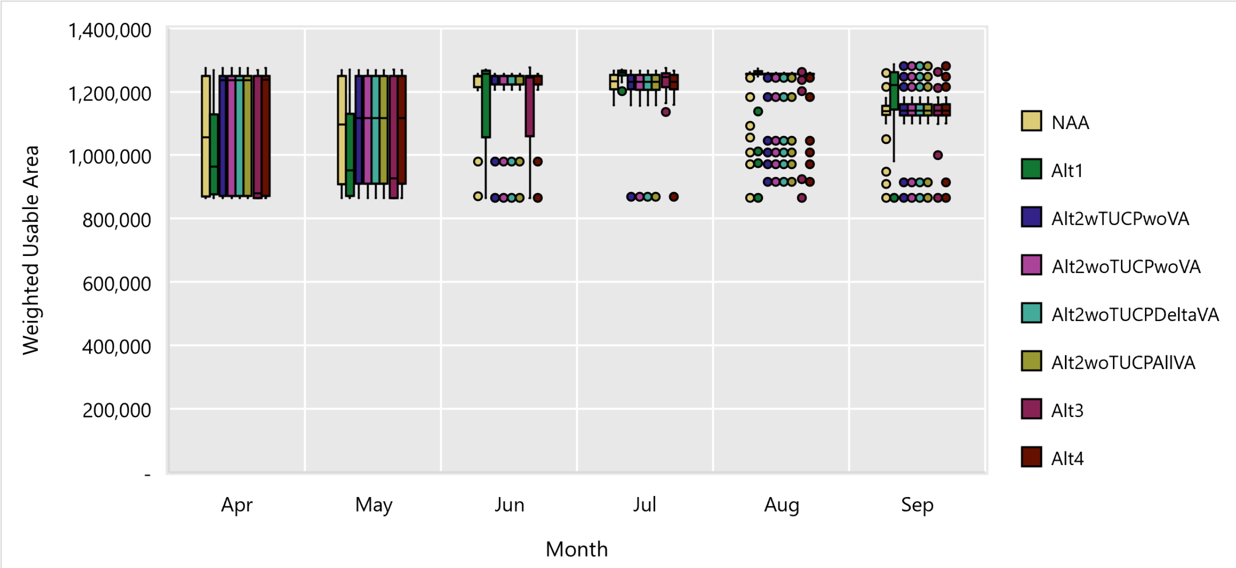

Figure N.2-12. Expected Total WUA for Steelhead Fry Rearing in the Stanislaus River Downstream of Goodwin Dam the NAA and Alternatives 1-4 by Month

Juvenile Rearing

The results for both the BA and EIS modeled scenarios generally show modest increases in mean juvenile rearing WUA from critical to wet water years, although for most of the scenarios WUA is slightly higher for below normal water years than for above normal years (Table N.2-10 and Table N.2-11). This pattern of variation reflects the steelhead juvenile WUA curves (Figure N.2-5), which show reduced rearing WUA with increased flow for the long Riverbank segment, but little overall change in the other curves. For the EIS modeled scenarios, most differences in steelhead mean fry rearing WUA between the scenarios and the NAA are small, with no differences exceeding 5% (Table N.2-10). The largest differences are for Alt 1, with a 2.8% reduction in critical years and a 3.0% increase for wet years (Table N.2-10). The other scenarios mostly show small increases in mean WUA, ranging from a 0.3% reduction for Alt 3 in above normal water years to a 2.2% increase for three different scenarios in critical water years (Table N.2-11).

Table N.2-10. Expected Mean Total WUA for Steelhead Juvenile Rearing in the Stanislaus River for EXP1, EXP3, the NAA, and Four Phases of Alternative 2.

WYT	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	880,409	1,181,913	1,269,808	1,272,993	1,272,542	1,273,384	1,273,403
AN	936,491	1,091,198	1,246,012	1,258,577	1,258,455	1,258,457	1,258,446
BN	956,314	1,024,683	1,242,934	1,262,544	1,258,596	1,258,596	1,258,735
Dry	1,108,528	996,797	1,216,600	1,237,921	1,234,875	1,234,865	1,234,863
Critical	929,893	884,748	1,185,812	1,210,502	1,211,607	1,211,764	1,211,684
All	959,145	1,021,100	1,230,704	1,247,441	1,246,593	1,246,830	1,246,825

Table N.2-11. Expected Mean Total WUA for Steelhead Juvenile Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	1,269,808	1,308,471	1,272,993	1,272,542	1,273,384	1,273,403	1,267,186	1,272,935
AN	1,246,012	1,275,366	1,258,577	1,258,455	1,258,457	1,258,446	1,241,820	1,258,582
BN	1,242,934	1,269,852	1,262,544	1,258,596	1,258,596	1,258,735	1,260,734	1,262,591
Dry	1,216,600	1,249,717	1,237,921	1,234,875	1,234,865	1,234,863	1,237,369	1,237,919
Critical	1,185,812	1,153,259	1,210,502	1,211,607	1,211,764	1,211,684	1,185,174	1,210,527
All	1,230,704	1,242,928	1,247,441	1,246,593	1,246,830	1,246,825	1,235,571	1,247,444
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	1,269,808	3.04	0.25	0.22	0.28	0.28	-0.21	0.25
AN	1,246,012	2.36	1.01	1.00	1.00	1.00	-0.34	1.01
BN	1,242,934	2.17	1.58	1.26	1.26	1.27	1.43	1.58
Dry	1,216,600	2.72	1.75	1.50	1.50	1.50	1.71	1.75
Critical	1,185,812	-2.75	2.08	2.18	2.19	2.18	-0.05	2.08
All	1,230,704	0.99	1.36	1.29	1.31	1.31	0.40	1.36

Figure N.2-13 and Figure N.2-14 show the full variation in estimated juvenile rearing WUA for steelhead under the BA and EIS modeled scenarios, respectively. The upper and lower limits of the range in WUA values are determined by the ranges of the juvenile rearing WUA curves from which they are estimated (Figure N.2-5). Under the BA modeled scenarios, the median WUA values of the four phases of Alternative 2 are similar to each other throughout the year and are consistently higher than EXP1 and EXP3 medians in April through October (Figure N.2-13). The NAA median values are similar to the medians of four phases of Alternative 2 in the juvenile rearing months, except in January when the NAA has a higher median, and in February, when the NAA has a lower median. In the EIS modeled scenarios, the NAA median WUA value is similar to the medians of the four phases of Alternative 2 and Alternative 4 most of the months, but is slightly higher in January and much lower in February (Figure N.2-14). Alternative 1 stands out with higher WUA values than the other alternatives in November through January, a similar value in February, and greater or lower values in March through October.

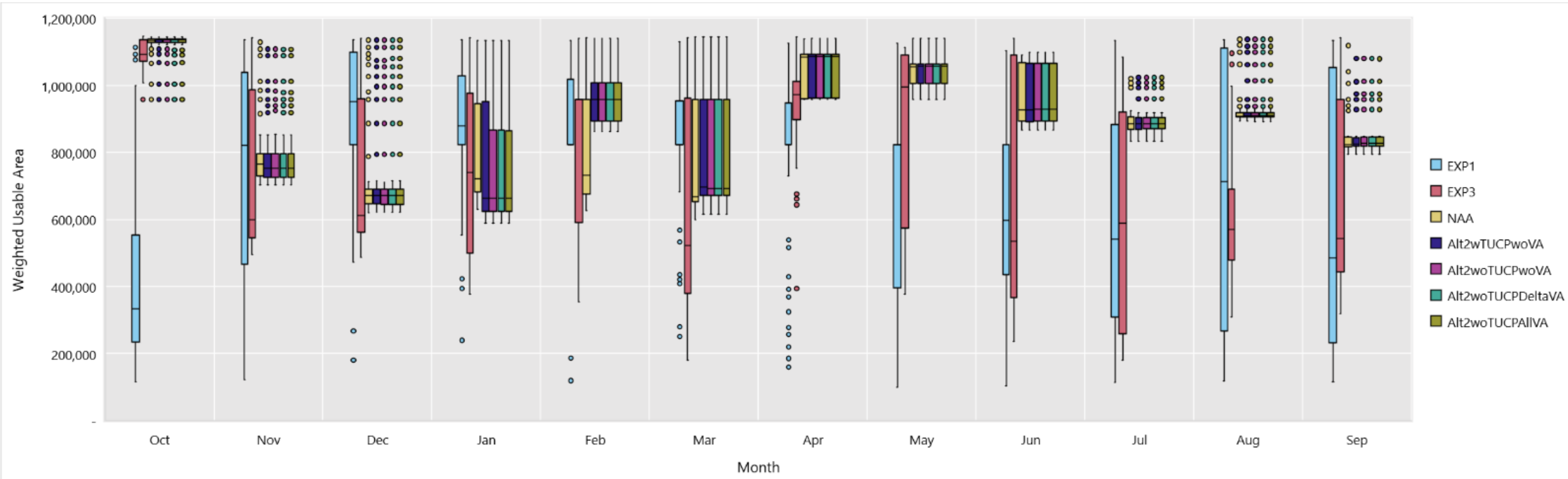

Figure N.2-13. Expected Total WUA for Steelhead Juvenile Rearing in the Stanislaus River Downstream of Goodwin Dam for EXP1, EXP3, the NAA, and Four Phases of Alternative 2 by Month

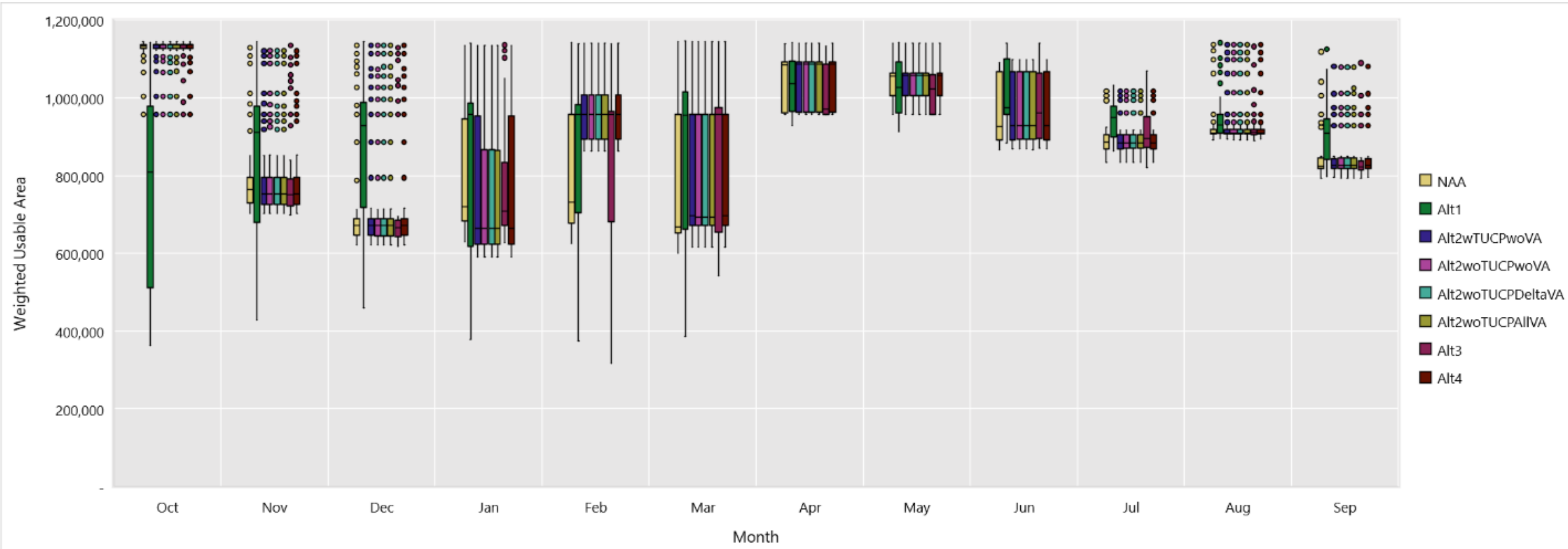

Figure N.2-14. Expected Total WUA for Steelhead Juvenile Rearing in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

N.2.3.1.3 Rearing Area of Suitable Habitat (ASH)

Table N.2-12 through Table N.2-15 provide the rearing ASH results for steelhead fry and juveniles under the BA modeled scenarios and EIS modeled scenarios. The results are the mean ASHs for the months of rearing for the entire 56 miles of the lower Stanislaus River from Knights Landing to the San Joaquin River confluence for all years analyzed. The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table N.2-13 and Table N.2-15).

Fry Rearing

The results for both the BA and EIS modeled scenarios consistently show increasing mean fry rearing ASH from critical to wet water years (Table N.2-12 and Table N.2-13). This pattern of variation reflects the consistent increases in steelhead fry ASH with increasing flow, including for the river as whole (Table N.2-2). For the EIS modeled scenarios, differences in steelhead mean fry rearing ASH between the scenarios and the NAA are small, with no differences exceeding 5%. The largest differences include a 4.8% increase in ASH for Alternative 1 in critically dry water years and 2.6% reductions for dry water years under the four phases of Alternative 2 and Alternative 4 (Table N.2-13). In general, Alt 1 shows the largest differences, which are mostly increases in ASH from the NAA.

Table N.2-12. Expected Mean Total ASH for Steelhead Fry Rearing in the Stanislaus River for EXP1, EXP3, the NAA, and Four Phases of Alternative 2.

WYT	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	631,598	783,435	813,964	806,783	806,761	806,761	806,762
AN	588,563	694,968	747,289	745,138	745,115	745,115	745,153
BN	573,125	670,791	740,526	733,299	733,226	733,223	733,255
Dry	571,913	607,302	700,095	681,747	681,734	681,735	681,732
Critical	422,549	586,882	655,857	663,864	667,801	667,802	667,802
All	536,440	659,152	721,833	718,515	719,832	719,832	719,841

Table N.2-13. Expected Mean Total ASH for Steelhead Fry Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	813,964	805,708	806,783	806,761	806,761	806,762	799,791	806,779
AN	747,289	759,593	745,138	745,115	745,115	745,153	744,123	745,138
BN	740,526	746,765	733,299	733,226	733,223	733,255	740,077	733,298
Dry	700,095	727,898	681,747	681,734	681,735	681,732	709,069	681,737
Critical	655,857	687,527	663,864	667,801	667,802	667,802	658,278	663,868
All	721,833	737,924	718,515	719,832	719,832	719,841	720,617	718,513
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	813,964	-1.01	-0.88	-0.88	-0.88	-0.88	-1.74	-0.88
AN	747,289	1.65	-0.29	-0.29	-0.29	-0.29	-0.42	-0.29
BN	740,526	0.84	-0.98	-0.99	-0.99	-0.98	-0.06	-0.98
Dry	700,095	3.97	-2.62	-2.62	-2.62	-2.62	1.28	-2.62
Critical	655,857	4.83	1.22	1.82	1.82	1.82	0.37	1.22
All	721,833	2.23	-0.46	-0.28	-0.28	-0.28	-0.17	-0.46

Figure N.2-15 and Figure N.2-16 show the full variation in estimated fry rearing ASH for steelhead under the BA and EIS modeled scenarios, respectively. Under the BA modeled scenarios, the four phases of Alternative 2 have median values above EXP1 and EXP3 in June through September and lie above or below these alternatives during April and May (Figure N.2-15). EXP1 has the highest ASH value in April and May, while it has the lowest value for the rest of the fry rearing period months. The NAA median values are similar to those of the four phases of Alternative 2 for most of the fry rearing months other than April, when the NAA has a higher median value. In the EIS modeled scenarios, the NAA median is similar to those of Alternatives 2 and 4 for most of the fry rearing period but it is higher in April (Figure N.2-16). Alternatives 1 and 3 have higher median values in comparison to the other scenarios through much of the fry rearing period.

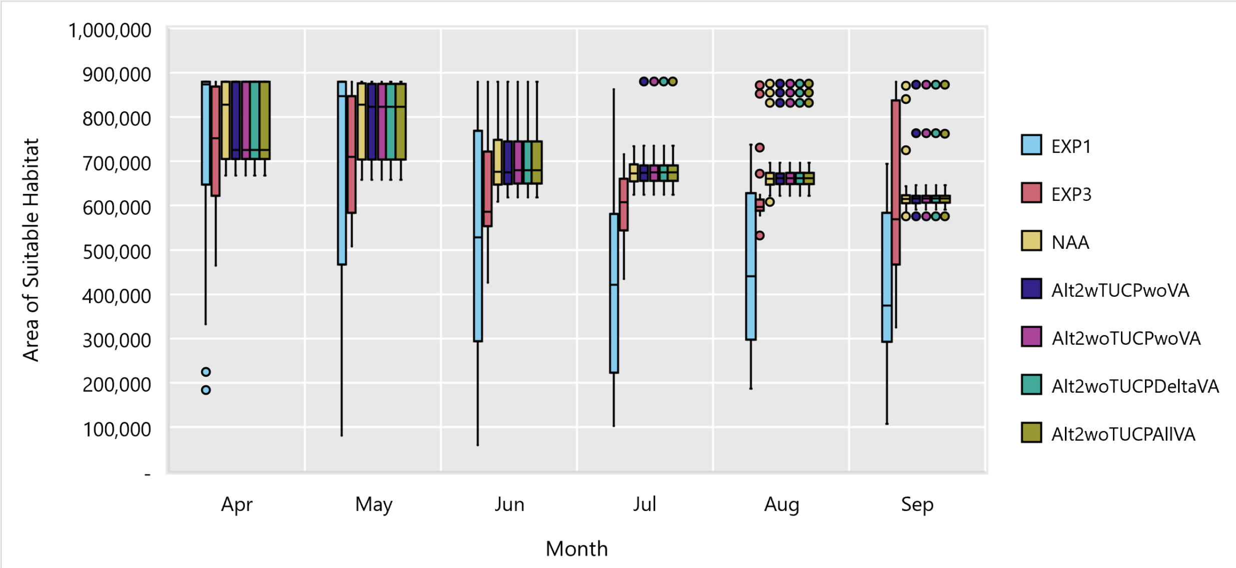

Figure N.2-15. Expected Area of Suitable Habitat for Steelhead Fry Rearing in the Stanislaus River Downstream of Goodwin Dam for EXP1, EXP3, the NAA, and Four Phases of Alternative 2 for by Month

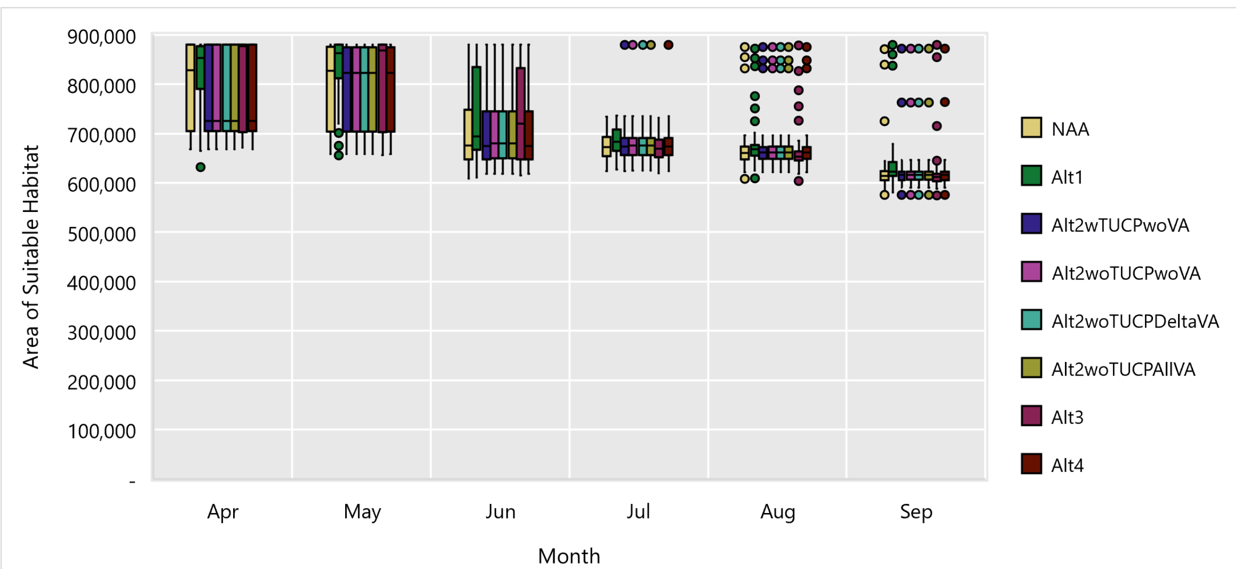

Figure N.2-16. Expected Area of Suitable Habitat for Steelhead Fry Rearing in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

Juvenile Rearing

The results for both the BA and EIS modeled scenarios consistently show increasing mean juvenile rearing ASH from critical to wet water years (Table N.2-14 and Table N.2-15). This pattern of variation reflects the consistent increases in steelhead juvenile ASH with increasing flow, including for the river as whole (Table N.2-2). For the EIS modeled scenarios, differences in steelhead mean fry rearing ASH between the scenarios and the NAA are small, with no differences exceeding 3%, except for 4.2% and 3.4% increases in ASH for dry water years under Alt. 3 and Alt. 2, respectively (Table N.2-15).

Table N.2-14. Expected Mean Total ASH for Steelhead Juvenile Rearing in the Stanislaus River for EXP1, EXP3, the NAA, and Four Alt 2 Scenarios.

WYT	EXP1	EXP3	NAA	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	681,632	772,032	761,062	586,301	586,090	586,093	586,071
AN	651,177	705,688	707,233	574,067	574,044	574,044	574,043
BN	647,658	662,012	697,937	566,793	557,565	557,565	557,535
Dry	639,495	589,998	630,889	474,765	472,106	472,131	472,124
Critical	475,472	525,155	600,721	459,212	459,337	459,480	459,435
All	595,999	633,126	668,680	519,735	517,892	517,946	517,920

Table N.2-15. Expected Mean Total ASH for Steelhead Juvenile Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
W	761,062	763,086	758,921	758,766	758,967	758,922	770,297	758,963
AN	707,233	706,819	709,455	709,420	709,420	709,437	701,395	709,457
BN	697,937	686,557	699,391	695,775	695,773	695,771	710,435	699,377
D	630,889	652,314	630,829	629,168	629,176	629,173	657,520	630,824
C	600,721	594,231	612,793	614,834	614,893	614,863	600,850	612,798
All	668,680	668,943	672,790	672,620	672,685	672,666	676,445	672,798
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
W	761,062	0.27	-0.28	-0.30	-0.28	-0.28	1.21	-0.28
AN	707,233	-0.06	0.31	0.31	0.31	0.31	-0.83	0.31
BN	697,937	-1.63	0.21	-0.31	-0.31	-0.31	1.79	0.21
D	630,889	3.40	-0.01	-0.27	-0.27	-0.27	4.22	-0.01
C	600,721	-1.08	2.01	2.35	2.36	2.35	0.02	2.01
All	668,680	0.04	0.61	0.59	0.60	0.60	1.16	0.62

Figure N.2-17 and Figure N.2-18 show the full variation in estimated juvenile rearing ASH for steelhead under the BA and EIS modeled scenarios, respectively. Under the BA modeled scenarios, the four phases of Alternative 2 median values are above those of EXP1 and EXP3 during June through September (Figure N.2-17). Depending on month, EXP1 has the highest or lowest median value of all scenarios, with much the lowest value in October and the highest median WUA in December through May. Through most of the juvenile rearing period, the NAA median values are similar to the medians of the four phases of Alternative 2 (Figure N.2-17 and Figure N.2-18). However, the NAA has a lower median value than the four phases of Alternative 2 in February, and a higher median in January and April.

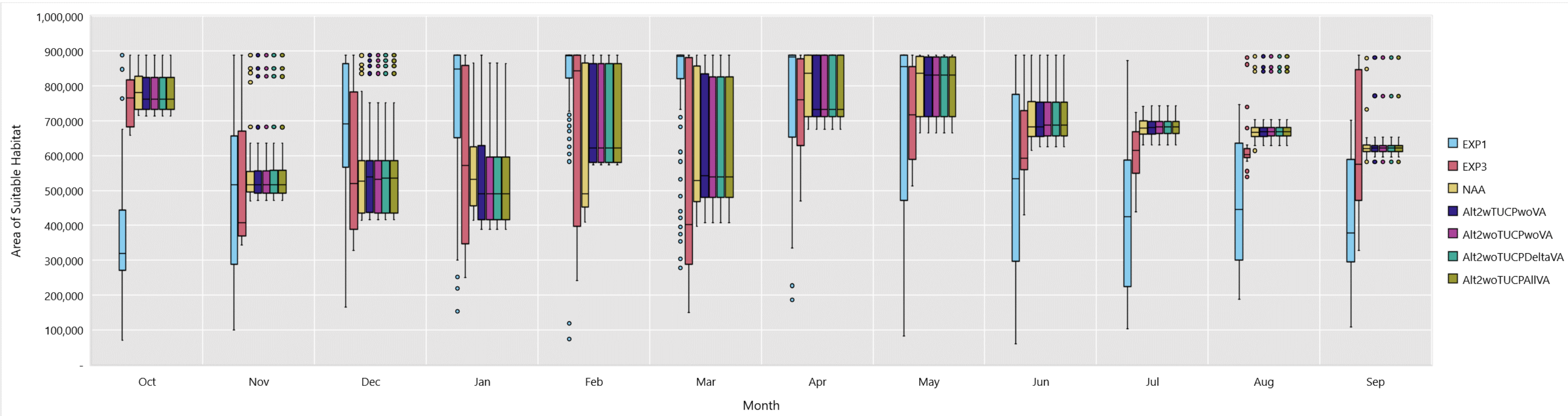

Figure N.2-17. Expected Area of Suitable Habitat for Steelhead Juvenile Rearing in the Stanislaus River Downstream of Goodwin Dam for EXP1, EXP3, the NAA, and Four Phases of Alternative 2 by Month

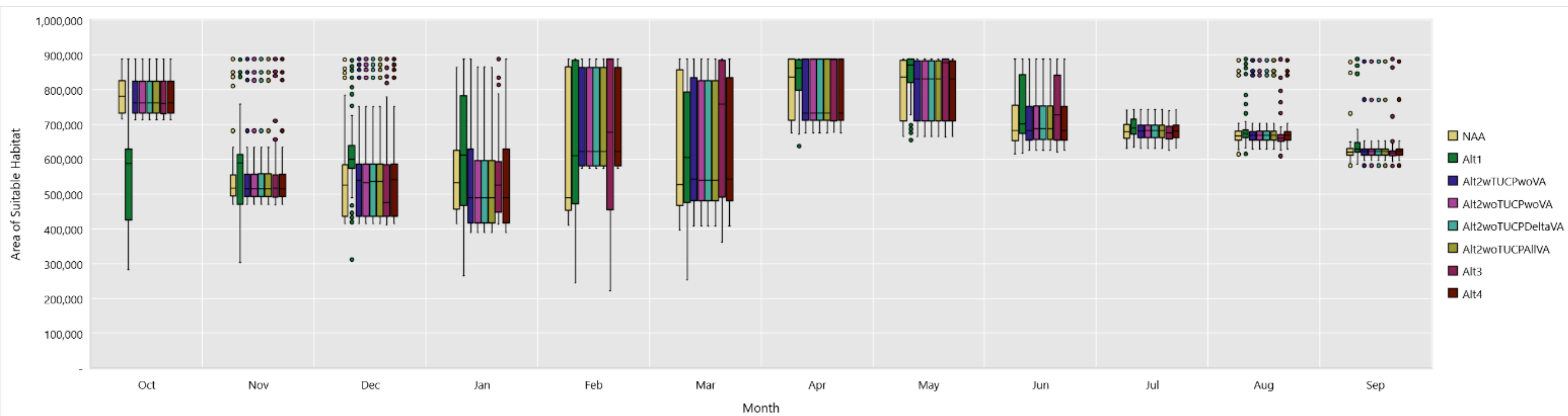

Figure N.2-18. Expected Area of Suitable Habitat for Steelhead Juvenile Rearing in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

N.2.3.2 Fall-run Chinook

N.2.3.2.1 Spawning Weighted Usable Area

Table N.2-16 provides the spawning WUA results for fall-run Chinook under the EIS modeled scenarios. The results are the mean total WUAs for all years analyzed, weighted by relative portion of each month included in the spawning period. Table N.2-16 includes the percent differences between the results of the NAA and the alternatives.

The results for both the EIS modeled scenarios show modest but consistent variation in mean spawning WUA with water year type for all scenarios except Alt 1 (Table N.2-16). All other scenarios show a steady reduction in mean WUA from critical water years to wet years (Table N.2-16). This pattern of variation reflects the fall-run spawning WUA curves, which show reduced WUA with increased flow at flows greater than about 200 cfs to 500 cfs, depending on river segment (Figure N.2-3). The high portions of the fall-run curves are spread out over greater flow ranges than is true for the steelhead curves (Figure N.2-2), which explains why the variation in mean WUA with water year type is less pronounced for fall-run than for steelhead (e.g., Table N.2-16 vs. Table N.2-3). Most of the modeled scenarios show only minor reductions in mean spawning WUA from the NAA, although reductions are generally greater for below normal water year (Table N.2-16). However, Alt 1 has much higher mean WUA than the NAA in dry, below normal, and above normal water years. Alt 3 also shows greater mean WUA than the NAA for all water year types, ranging up to 5.8% higher in above normal water years (Table N.2-16).

Table N.2-16. Expected Mean Total WUA for Fall-run Spawning in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	664,854	694,035	653,839	653,205	653,696	654,284	678,174	653,428
AN	782,495	928,681	779,310	779,270	779,270	779,270	828,330	779,314
BN	828,000	966,719	805,592	810,259	810,258	810,285	832,191	805,593
Dry	886,522	980,894	889,815	891,602	891,597	891,594	888,506	889,816
Critical	923,158	917,477	921,084	920,872	920,810	920,893	929,620	921,089
All	826,744	887,234	820,377	821,165	821,251	821,412	838,727	820,289
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	664,854	4.39	-1.66	-1.75	-1.68	-1.59	2.00	-1.72
AN	782,495	18.68	-0.41	-0.41	-0.41	-0.41	5.86	-0.41
BN	828,000	16.75	-2.71	-2.14	-2.14	-2.14	0.51	-2.71
Dry	886,522	10.65	0.37	0.57	0.57	0.57	0.22	0.37
Critical	923,158	-0.62	-0.22	-0.25	-0.25	-0.25	0.70	-0.22
All	826,744	7.32	-0.77	-0.67	-0.66	-0.64	1.45	-0.78

Figure N.2-19 shows the full variation in estimated spawning WUA for fall-run under the EIS modeled scenarios. The upper and lower limits or the range in WUA values are determined by the ranges of the spawning WUA curves from which they are estimated (Figure N.2-3). Under the modeled scenarios, the alternatives have similar median values for November and December and are above the NAA (Figure N.2-19). In October, Alt1 has the highest median value while the other alternatives and NAA are similar.

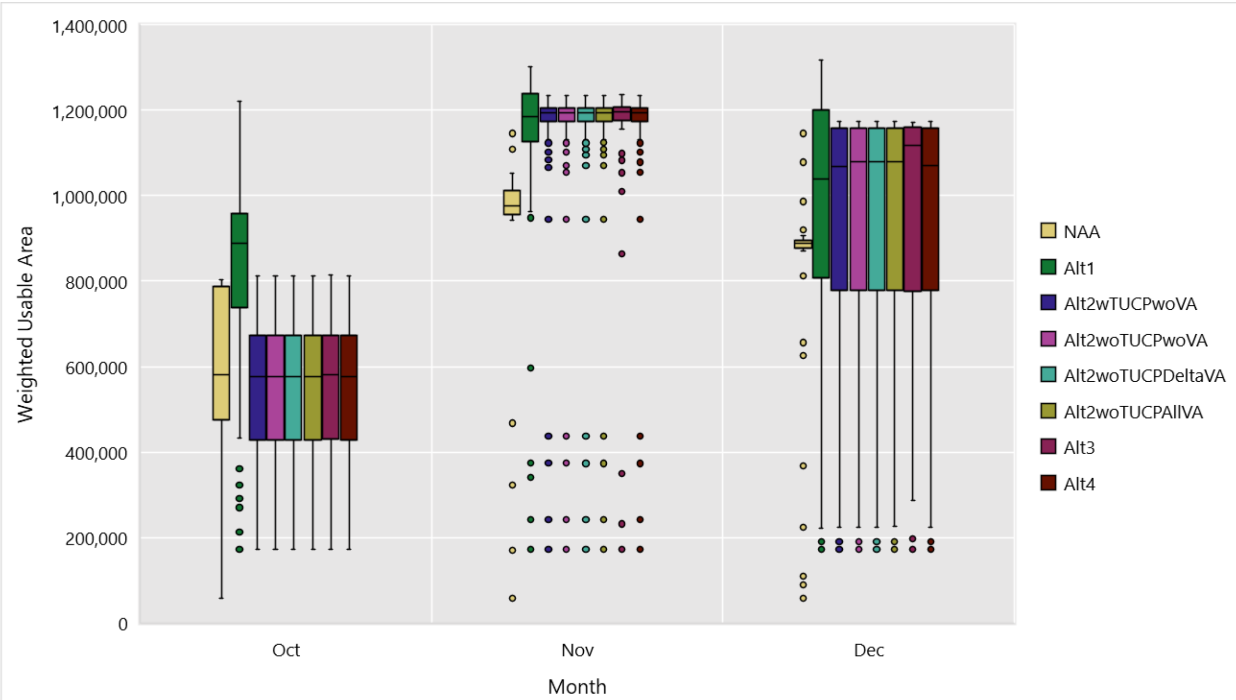

Figure N.2-19. Expected Mean WUA for Fall-run Chinook Salmon Spawning in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

N.2.3.2.2 Rearing Weighted Usable Area

Table N.2-17 and Table N.2-18 provide the rearing WUA results for fall-run Chinook fry and juveniles under the BA modeled scenarios and EIS modeled scenarios. The results are the mean WUAs for the months of rearing summed over the four river segments for all years analyzed. The tables include the percent differences between the results of the NAA and the alternatives (Table N.2-17 and Table N.2-18).

Fry Rearing

The results generally show minor differences in mean fry rearing WUA between critical and dry water year types for the EIS modeled scenarios and gradual reductions in wetter years (Table N.2-17). This pattern of variation reflects the fall-run fry WUA curves (Figure N.2-6), which show reduced WUA with increased flow, especially in Orange Blossom Bridge and Riverbank, which are the longest segments. Most differences in fall-run mean fry rearing WUA between the EIS modeled scenarios and the NAA are moderate and constitute increases in WUA, but the differences for Alt 1 and Alt 3 include reductions in WUA, including a maximum reduction of 5.2% for Alt 1 in critical water years (Table N.2-17). For the other scenarios, all differences are positive, ranging from 2.7% higher WUA in above normal water years for Alt 4 and all phases of Alt 2 to 7.2% higher in critical water years for all these scenarios.

Table N.2-17. Expected Mean Total WUA for Fall-run Fry Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	1,610,528	1,696,957	1,671,446	1,671,480	1,671,467	1,671,490	1,582,397	1,671,444
AN	1,696,363	1,691,179	1,742,663	1,742,571	1,742,573	1,742,568	1,655,789	1,742,672
BN	1,736,593	1,755,670	1,793,871	1,800,665	1,800,663	1,800,859	1,712,399	1,794,105
Dry	1,794,385	1,862,025	1,890,772	1,890,738	1,890,665	1,890,676	1,771,602	1,890,795
Critical	1,789,854	1,696,723	1,919,102	1,918,998	1,918,875	1,918,987	1,773,098	1,919,100
All	1,747,767	1,749,837	1,834,280	1,835,252	1,835,195	1,835,269	1,723,339	1,834,319
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	1,610,528	5.37	3.78	3.78	3.78	3.79	-1.75	3.78
AN	1,696,363	-0.31	2.73	2.72	2.72	2.72	-2.39	2.73
BN	1,736,593	1.10	3.30	3.69	3.69	3.70	-1.39	3.31
Dry	1,794,385	3.77	5.37	5.37	5.37	5.37	-1.27	5.37
Critical	1,789,854	-5.20	7.22	7.22	7.21	7.21	-0.94	7.22
All	1,747,767	0.12	4.95	5.01	5.00	5.01	-1.40	4.95

Figure N.2-20 shows the full variation in estimated fry rearing WUA for fall-run under the EIS modeled scenarios. The upper and lower limits of the range in WUA values are determined by the ranges of the fry rearing WUA curves from which they are estimated (Figure N.2-6). Under the EIS modeled scenarios, the four phases of Alternative 2 and Alternative 4 have median values similar to one another in all months of the fry rearing period (Figure N.2-20). These medians are greater than the NAA median in February through April and are below the NAA median in January. The Alternative 1 and 3 medians are most different from the medians of the other alternatives.

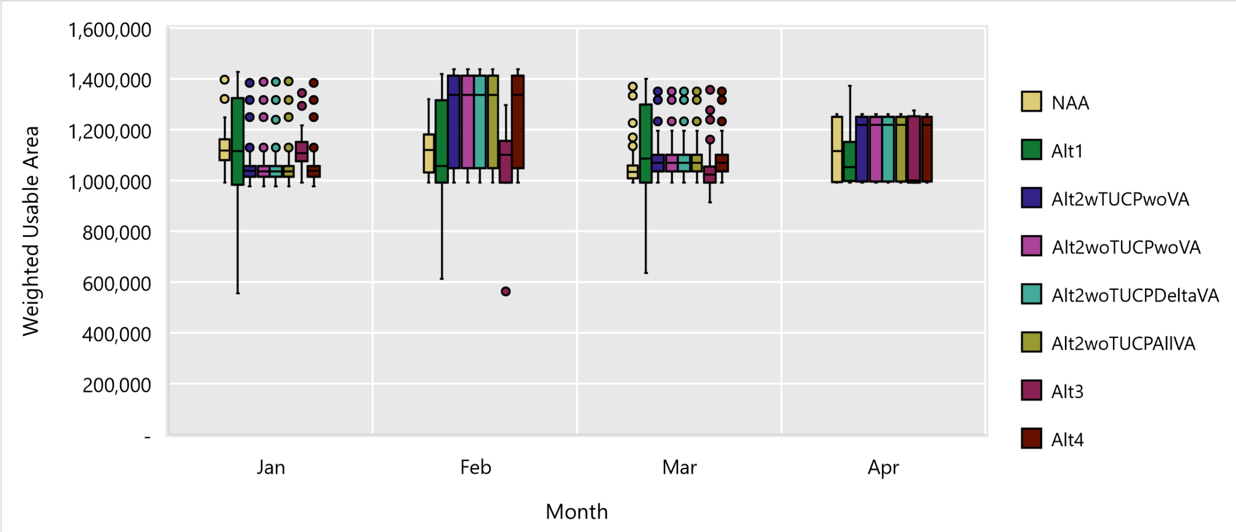

Figure N.2-20. Expected Total WUA for Fall-run Chinook Salmon Fry Rearing in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

Juvenile Rearing

The results for both the BA and EIS modeled scenarios mostly show increased reduction in fall-run juvenile rearing WUA from critical to below normal water years and reduced WUA between above normal and wet years (Table N.2-18). This pattern of variation reflects the fall-run juvenile WUA curves (Figure N.2-7), which show increased rearing WUA with increased flow for flows below about 700 cfs and lower rearing WUA with increased flow at higher flows. This pattern of variation is most pronounced for the long Riverbank segment. Most differences in steelhead mean fry rearing WUA between the EIS modeled scenarios and the NAA are moderate and constitute increases in WUA. The only reduction is a 1% reduction for above normal water years under Alt 3. Increases range from 0.6% in critical water years under Alt 3 to 6.4% under Alt 1 (Table N.2-18).

Table N.2-18. Expected Mean Total WUA for Fall-run Juvenile Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	1,286,854	1,327,126	1,323,742	1,323,697	1,323,691	1,323,684	1,304,714	1,323,742
AN	1,306,948	1,319,454	1,348,663	1,348,626	1,348,627	1,348,625	1,293,262	1,348,667
BN	1,322,629	1,337,234	1,379,245	1,370,084	1,370,084	1,370,094	1,360,889	1,379,353
Dry	1,292,021	1,374,630	1,351,846	1,352,350	1,352,344	1,352,337	1,335,443	1,351,833
Critical	1,232,064	1,260,189	1,299,390	1,299,801	1,300,014	1,300,001	1,239,057	1,299,401
All	1,276,882	1,313,039	1,331,556	1,330,393	1,330,463	1,330,457	1,294,667	1,331,574

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	1,286,854	3.13	2.87	2.86	2.86	2.86	1.39	2.87
AN	1,306,948	0.96	3.19	3.19	3.19	3.19	-1.05	3.19
BN	1,322,629	1.10	4.28	3.59	3.59	3.59	2.89	4.29
Dry	1,292,021	6.39	4.63	4.67	4.67	4.67	3.36	4.63
Critical	1,232,064	2.28	5.46	5.50	5.52	5.51	0.57	5.47
All	1,276,882	2.83	4.28	4.19	4.20	4.20	1.39	4.28

Figure N.2-21 shows the full variation in estimated juvenile rearing WUA for fall-run under the EIS modeled scenarios. The upper and lower limits of the range in WUA values are determined by the ranges of the juvenile rearing WUA curves from which they are estimated (Figure N.2-7). The four phases of Alternative 2 and Alternative 4 have similar median WUA values during the February through June period of fall-run juvenile rearing (Figure N.2-21). The Alternatives 2 and 4 medians are much higher than the NAA median value in February but are similar in the other months. The Alternatives 1 and 3 medians are different than those of the other alternatives in March through April.

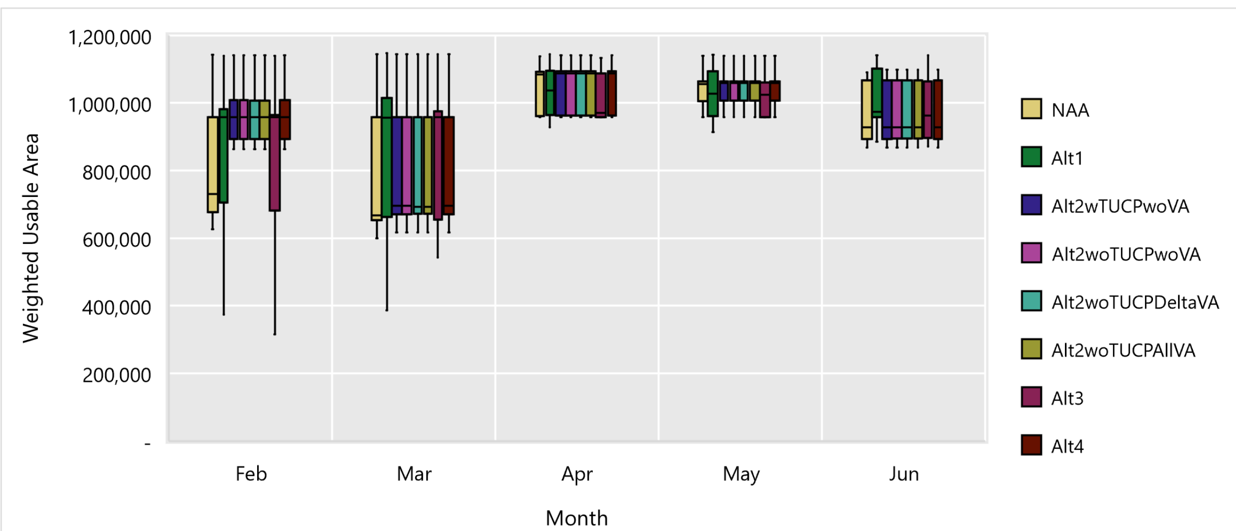

Figure N.2-21. Expected Total WUA for Fall-run Chinook Salmon Juvenile Rearing in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

N.2.3.2.3 Rearing Area of Suitable Habitat (ASH)

Table N.2-19 and Table N.2-20 provide the rearing ASH results for fall-run fry and juveniles under the EIS modeled scenarios. The results are the mean ASHs for the months of rearing for the entire 56 miles of the lower Stanislaus River from Knights Landing to the San Joaquin River confluence for all years analyzed. The table for the EIS modeled scenarios includes the percent differences between the results of the NAA and the alternatives (Table N.2-20).

Fry Rearing

The results for both the BA and EIS modeled scenarios consistently show increasing mean fry rearing ASH from critical to wet water years (Table N.2-19). This pattern of variation reflects the consistent increases in fall-run fry ASH with increasing flow, including for the river as whole (Table N.2-2). For the EIS modeled scenarios, differences in fall-run mean fry rearing ASH are inconsistent, including increases of 12.9% and 17.5% in ASH for dry water years under Alt 1 and Alt 3, and increase of 10.2%, an 8.4% for wet and below normal water years, respectively under Alternative 3 (Table N.2-19). Most differences from the No Action Alternative constitute increases in fry rearing ASH.

Table N.2-19. Expected Mean Total ASH for Fall-run Fry Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	580,041	593,273	586,301	586,090	586,093	586,071	639,119	586,305
AN	563,276	561,921	574,067	574,044	574,044	574,043	555,385	574,070
BN	554,166	546,480	566,793	557,565	557,565	557,535	600,697	566,752
Dry	446,976	504,525	474,765	472,106	472,131	472,124	525,128	474,758
Critical	430,665	434,556	459,212	459,337	459,480	459,435	432,166	459,212
All	500,739	513,441	519,735	517,892	517,946	517,920	533,565	519,729
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	580,041	2.28	1.08	1.04	1.04	1.04	10.19	1.08
AN	563,276	-0.24	1.92	1.91	1.91	1.91	-1.40	1.92
BN	554,166	-1.39	2.28	0.61	0.61	0.61	8.40	2.27
Dry	446,976	12.88	6.22	5.62	5.63	5.63	17.48	6.22
Critical	430,665	0.90	6.63	6.66	6.69	6.68	0.35	6.63
All	500,739	2.54	3.79	3.43	3.44	3.43	6.56	3.79

Juvenile Rearing

The results for both the BA and EIS modeled scenarios consistently show increasing mean juvenile rearing ASH from critical to wet water years (Table N.2-20). This pattern of variation reflects the consistent increases in fall-run juvenile ASH with increasing flow, including for the river as whole (Table N.2-2). For the EIS modeled scenarios, differences in fall-run mean juvenile rearing ASH between the scenarios and the NAA include very large increases, including increases of 23.7% and 14.9% for dry and critically dry years, respectively, under Alt 1 and increases of 10.6% and 33.0% for wet and dry water years, respectively, under Alt 3 (Table N.2-20). Combining all water year types, Alt 1 and Alt 3 show major increases in rearing ASH, while the other alternatives show small reductions (Table N.2-20).

Table N.2-20. Expected Mean Total ASH for Fall-run Juvenile Rearing in the Stanislaus River for the NAA and Alternatives 1-4. The Lower Panel Gives the Percent Differences of the Alternatives and the NAA.

WYT	NAA	Alt 1	Alt2wTUCP woVA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA	Alt 3	Alt 4
Wet	663,498	645,144	647,825	647,682	647,693	647,690	732,905	647,827
AN	579,696	591,319	579,663	579,643	579,643	579,674	583,796	579,665
BN	557,774	546,640	531,475	522,616	522,592	522,608	598,021	531,296
Dry	366,476	453,290	361,601	360,918	360,935	360,928	487,520	361,590
Critical	320,552	368,241	338,880	341,675	341,735	341,734	331,027	338,881
All	470,488	497,147	468,494	467,965	467,987	467,991	516,425	468,466
WYT	**NAA**	**Alt 1**	**Alt2wTUCP woVA**	**Alt2woTUCP woVA**	**Alt2woTUCP DeltaVA**	**Alt2woTUCP AllVA**	**Alt 3**	**Alt 4**
Wet	663,498	-2.77	-2.36	-2.38	-2.38	-2.38	10.46	-2.36
AN	579,696	2.00	-0.01	-0.01	-0.01	0.00	0.71	-0.01
BN	557,774	-2.00	-4.71	-6.30	-6.31	-6.30	7.22	-4.75
Dry	366,476	23.69	-1.33	-1.52	-1.51	-1.51	33.03	-1.33
Critical	320,552	14.88	5.72	6.59	6.61	6.61	3.27	5.72
All	470,488	5.67	-0.42	-0.54	-0.53	-0.53	9.76	-0.43

Figure N.2-22 and Figure N.2-23 show the full monthly variation in estimated fry and juvenile rearing ASH for fall-run under EIS modeled scenarios. For fry rearing, the median value for the NAA is similar to the medians of Alternatives 2 and 4 in March, but the NAA median is higher January and April and lower in February (Figure N.2-22). For most of the scenarios, January and March have the lowest median WUA values and April the highest values. For juvenile rearing, the median values are generally lowest in March, and highest in May (Figure N.2-23). The NAA is similar to the four phases of Alternative 2 and Alternative 4 throughout the juvenile rearing period, except in February, when it is lower, and April, when it is higher.

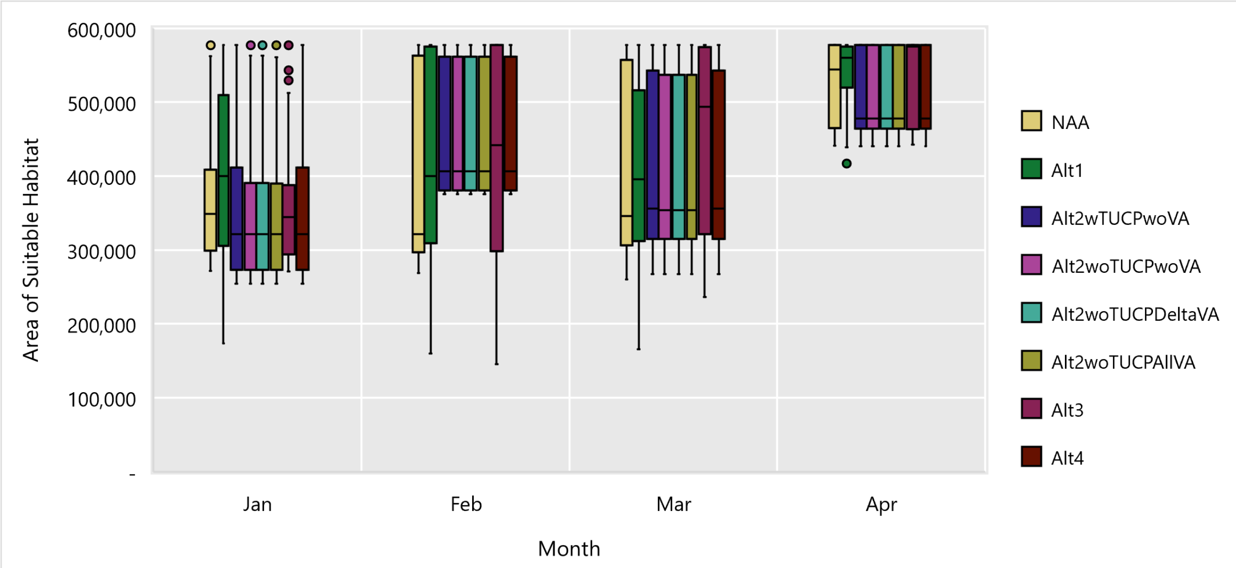

Figure N.2-22. Expected Area of Suitable Habitat for Fall-run Fry Rearing in the Stanislaus River Downstream of Goodwin Dam for EXP1, EXP3, the NAA, and Four Phases of Alternative 2 for by Month

This figure shows data also presented in data tables in this file.

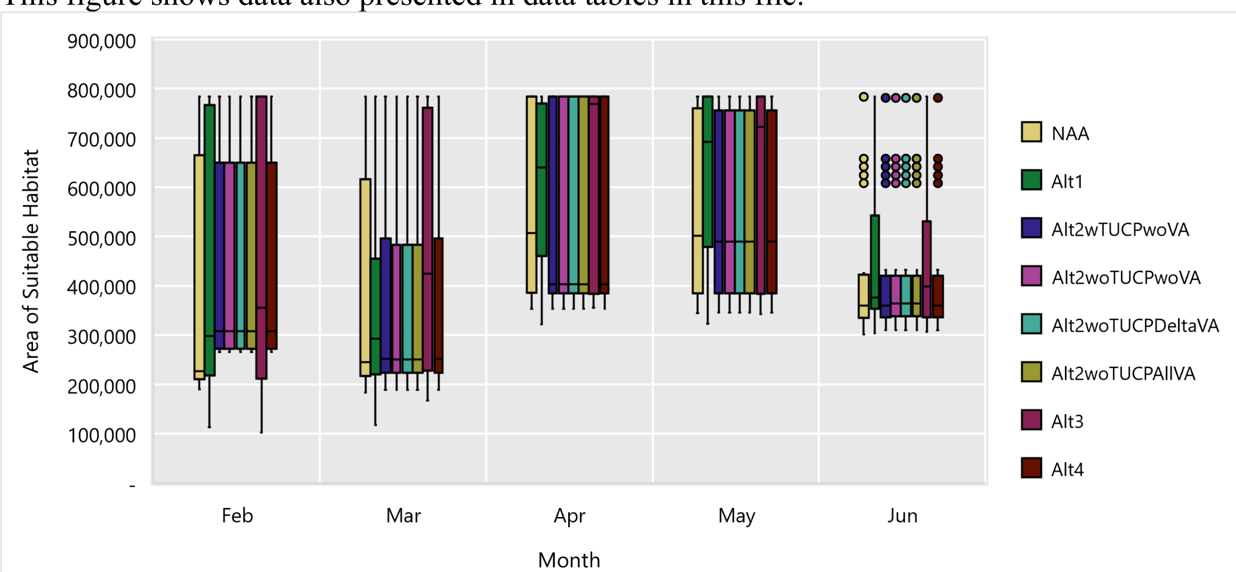

Figure N.2-23. Expected Area of Suitable Habitat for Fall-run Juvenile Rearing in the Stanislaus River Downstream of Goodwin Dam for the NAA and Alternatives 1-4 by Month

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