Appendix L

Potential Juvenile Rearing Habitat Expansion Actions in the Lower Yuba River

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Aquarium Pool
Photo courtesy of William T. Mitchell, ICF International, 2008

L.1 Description

The juvenile rearing habitat expansion actions (potential actions) address historical reductions in off-channel rearing habitat that currently limit production and life history variability of juvenile spring-run Chinook salmon and steelhead in the Lower Yuba River (Figure L-1). The South Yuba River Citizens League (SYRCL) recently prepared a proposal that focuses initially on planning and design for restoration of off-channel rearing habitat in the 3-mile reach below the Highway 20 Bridge (cbec 2010). This is considered a key reach for restoration because of its proximity to the primary spring-run Chinook salmon and steelhead spawning reaches, favorable rearing temperatures, and the limited extent of off-channel habitat. The juvenile rearing habitat expansion actions discussed here would complement a current Anadromous Fish Restoration Program (AFRP)-funded pilot restoration project and utilize a 180-acre conservation easement on land in the Yuba Goldfields owned by Western Aggregates. The general targets identified by SYRCL for the initial phase of the action are restoration of 5 acres of backwater or side-channel habitat and restoration of 50 acres of functional floodplain with enhanced riparian habitat.

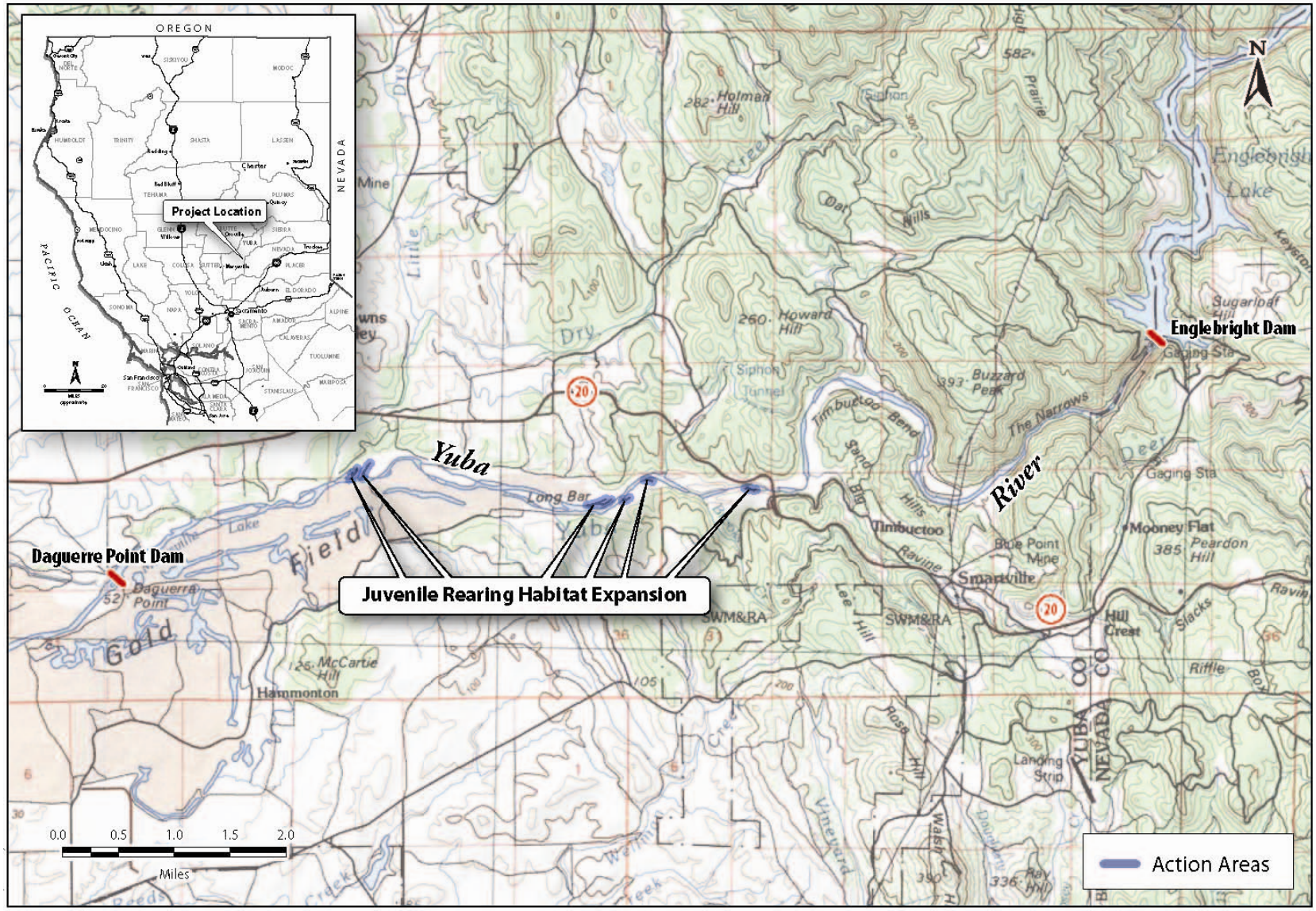

Figure L-1. Location of Potential Juvenile Rearing Habitat Expansion Actions in the Lower Yuba River

The goal of off-channel habitat enhancement is to increase the rearing capacity of the Lower Yuba River to support an increase in production of juvenile spring-run Chinook salmon. The potential actions for achieving this goal would connect, expand, and enhance existing off-channel habitats that, under existing conditions, have limited rearing potential because of their size, water depths, cover characteristics, and degree of connectivity with the main river. Potential expansion and restoration sites include abandoned river channels, overflow channels, flood swales, and associated backwaters that have been the subject of a fish stranding study since 2007 (Mitchell pers. comm.). In addition to investigating the factors influencing stranding risk, this study provided evidence of the significant rearing potential of off-channel habitats for Chinook salmon in the Lower Yuba River.

The primary objectives of the potential actions would be to improve the connectivity of existing off-channel habitats with the main river, and increase the quantity and quality of these habitats for spring and summer rearing of spring-run Chinook salmon. The key sites for this effort are abandoned river channels, overflow channels, and flood swales that are disconnected from the main river at their upper ends but support groundwater-fed channels in their lower reaches at summer and fall flows. Aerial photography and extensive field surveys of off-channel habitats since 2007 have revealed that these are common natural features of the Lower Yuba River floodplain. These off-channel areas are frequently connected to the main river during high winter flows, providing access for Chinook salmon fry that seek out shallow, lower-velocity shoreline and floodplain areas following emergence.

Following high winter flows, fish stranding surveys indicate that the quality of off-channel habitat varies as a function of water depth, cover availability, water quality, and the presence or absence of predators (Mitchell pers. comm.). Many of the surveyed floodplain habitats support fry for variable periods of time following winter flows but do not provide suitable rearing habitat after flows recede because they become too shallow, too warm, or lack sufficient cover to protect fry from piscivorous birds and other predators. However, long-term monitoring of several isolated groundwater-fed channels in 2008 confirmed that some sites can support high densities and growth of juvenile salmon and other native fish species through the spring and summer (Mitchell pers. comm.). Habitat conditions that appear to be important for extended off-channel rearing are the presence of groundwater flow, sufficient water depths, riparian and aquatic vegetation, and the absence of large predatory fish (e.g., pikeminnow).

While floodplain and off-channel habitats are sources of stranding mortality, recent studies have documented significant growth and potential survival benefits associated with floodplain and off-channel habitat use by Chinook salmon in the Central Valley (Limm and Marchetti 2009; Jeffres et al. 2008; Sommer et al. 2001, 2002). Compared to main channel habitats, important attributes of floodplain habitat generally include warmer water temperatures, abundant vegetation, higher prey densities (aquatic insects), lower water velocities, and lower predator abundance. Consequently, floodplain and other off-channel habitats serve important refuge and rearing functions for native fishes; these

habitats likely contributed substantially to the productive capacity and life history diversity of Chinook salmon and other fish species in the Sacramento River system before large-scale channel modifications, levee construction, and agricultural conversion of floodplains (Lindley et al. 2009, Yoshiyama et al. 1998). In gravel-bed rivers like the Yuba River, off-channel habitats serve similar ecological functions and may be especially important for juvenile salmon production, given historical reductions in floodplain habitat throughout the lower reaches of the Sacramento River system.

L.1.1 Proposed Design Concept for Juvenile Rearing Habitat Enhancement

The general design concept for rearing habitat enhancement involves excavating and lowering the outlets and interiors of selected overflow channels, flood swales, and isolated groundwater channels and ponds to connect these features to the main river and increase the area of suitable water depths and cover for the target species and life stages. The upper portions of the bars or inlets leading to these off-channel habitats would remain undisturbed to preserve the natural surface and groundwater flow characteristics of the site. A key design feature is the alignment of off-channel habitats along existing overflow channels and riparian vegetation to capitalize on the natural habitat-forming processes inherent at these locations, as well as minimize the volume of material that would need to be excavated to achieve the desired elevations. Large boulder and/or wood complexes would be installed, as needed, to control flows, promote scour, and maintain habitat diversity in areas devoid of existing riparian vegetation or other geomorphic controls (e.g., bedrock).

Figure L-2 shows the locations of six potential rearing habitat expansion sites identified by the Licensees and described below. Figures L-3 through L-6 illustrate the general concepts for these six sites. Selection criteria for these sites included detectable surface water and groundwater flow, presence of riparian and/or aquatic vegetation, proximity to the main channel, and construction access. These sites also were identified because juvenile salmonids and suitable summer water temperatures have been documented at these sites during recent off-channel stranding surveys (Mitchell pers. comm.).

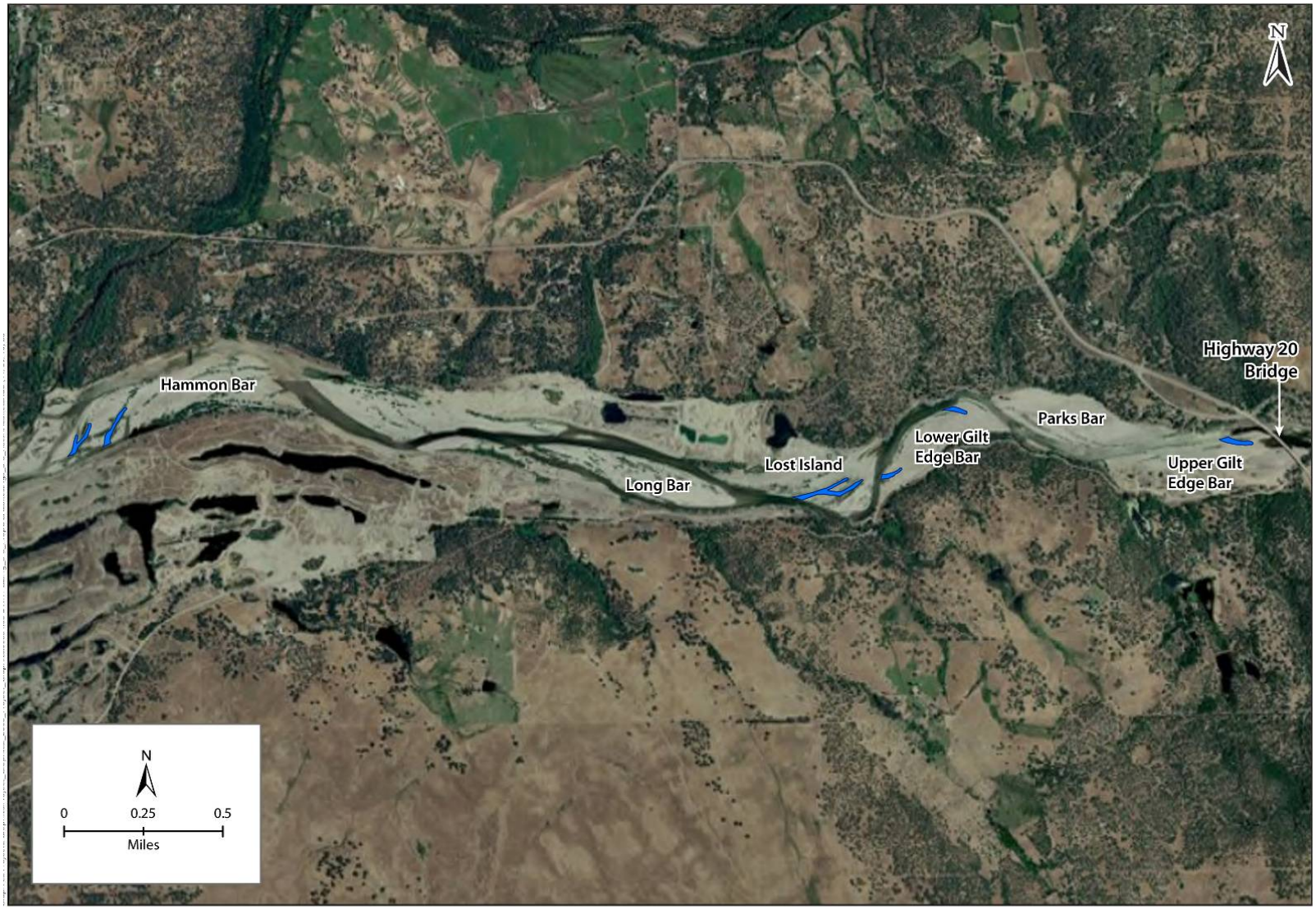

Figure L-2. Potential Juvenile Rearing Habitat Expansion Sites (in blue)

Hammon Bar Side Channel
Photo courtesy of William T. Mitchell, ICF International, 2007

- **Sites 1a and 1b – Hammon Bar (Figure L-3).** The western end of Hammon Bar is characterized by a series of remnant channels that intersect the bar and lead to a large side channel sustained by groundwater flows from the river and the Yuba Goldfields. This side channel supports high densities of juvenile Chinook salmon, steelhead, and other native fishes during spring and summer. Off-channel rearing habitat could be created by excavating two to three channels along the alignments of the remnant channels and preserving the existing riparian vegetation bordering these channels. Approximately 4,000 m^2 would be available as juvenile rearing habitat at Site 1a, and approximately 4,200 m^2 would be available at Site 1b.

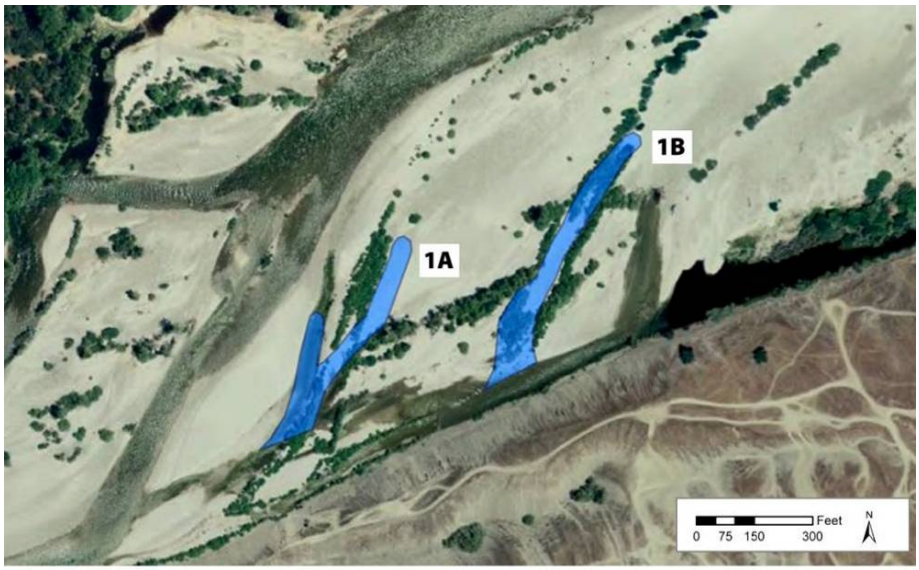

Figure L-3. Off-Channel Habitat Enhancement Concept at Hammon Bar

- **Site 2 – Lost Island (Figure L-4).** This bar is characterized by two large interconnected flood channels that, during low flows, become a series of isolated ponds and depressions formed by flood scour at the base of the existing riparian vegetation. Stranding of juvenile salmonids is frequently observed here because of the frequency of inundation and presence of low-velocity cover (Mitchell pers. comm.). Lowering the bed along the existing flood swales would eliminate the stranding risk and create off-channel rearing habitat. Approximately 8,300 m^2 would be available as juvenile rearing habitat at Site 2. Large boulder and/or woody complexes may be needed along portions of the channels to promote scour, enhance habitat quality, and ensure connectivity with the main river at low flows.

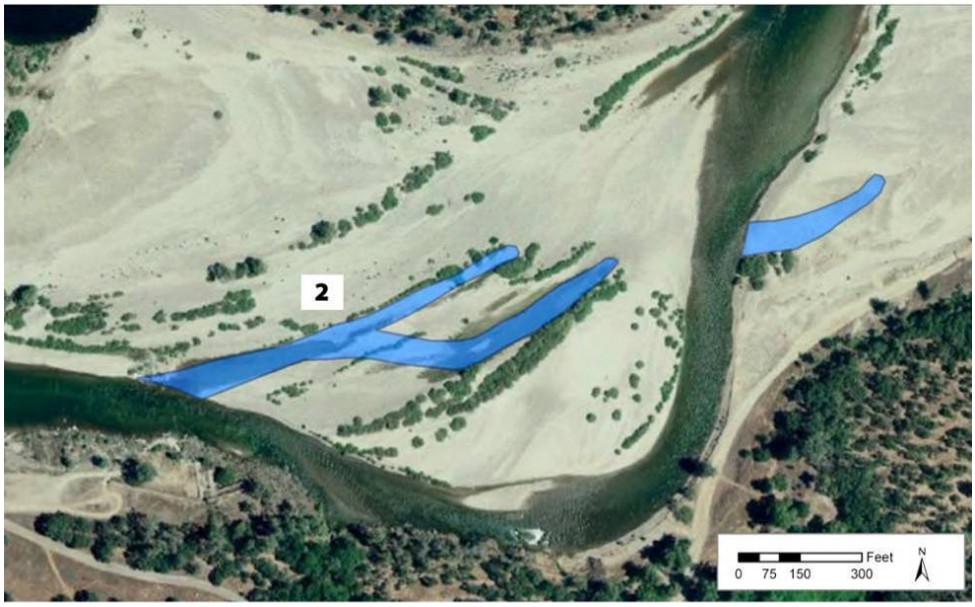

Figure L-4. Off-Channel Habitat Enhancement Concept at Lost Island

- **Sites 3a and 3b – Lower Gilt Edge Bar (Figure L-5).** Site 3b consists of a relatively deep scour feature associated with a band of riparian vegetation adjacent to the main river. The site is noteworthy because of significant groundwater flow and documentation of relatively high densities and growth of juvenile Chinook salmon through summer and fall 2008. The existing habitat would be expanded by removing the sediment plug at the outlet and extending the channel upstream along the existing flood swale. The channel area that would be available as juvenile rearing habitat at Site 3b is approximately 2,000 m^2.

  Additionally, the potential exists for creating one or two similar off-channel habitats farther downstream along the western shoreline of Lower Gilt Edge Bar. The low topography (i.e., swale-like nature) coupled with existing vegetation at several locations along the shoreline provides the potential for creating habitat conditions similar to that described for Site 3b. One potential site, Site 3a, similar in size to Site 3b, is shown in Figure L-5.

Figure L-5. Off-Channel Habitat Enhancement Concept at Lower Gilt Edge Bar

- **Site 4 – Upper Gilt Edge Bar (Figure L-6).** Site 4 is a small flood swale that would be improved by lowering the entire site adjacent to the existing band of riparian vegetation. The channel area that would be available as juvenile rearing habitat is approximately 3,400 m^2 .

Figure L-6. Off-Channel Habitat Enhancement Concept at Upper Gilt Edge Bar

Key assumptions for the potential juvenile rearing habitat expansion actions are that: (1) groundwater channels can be expanded relatively easily and cost effectively using moderate terra-forming techniques; and (2) constructed features would be sustained naturally for many years. As described above, potential habitat enhancement sites follow the alignments of previous river channels and existing flood channels. These areas appear to be ideal locations for creating and expanding juvenile rearing habitat because of the observed stability and persistence of groundwater channels in these areas. However, additional geomorphic and hydrographic analysis would be necessary to fully understand the processes that maintain these channels and their groundwater connections within the selected sites. Additional analyses may include determining the location and gradient of the groundwater table in vicinity of the habitat expansion sites, hydraulic modeling of river and off-channel enhancement areas to determine water surface elevations and associated duration and stage of overbank flow, and assessment of the stability and performance of boulder or large woody placements that may be proposed as part of the design. Sediment transport modeling may not be necessary given the apparent stability of the bars and existing groundwater channels under frequently recurring flood flows.

The number of off-channel habitat expansion sites and their precise locations, areas, and cross-sectional and longitudinal profiles would be determined following completion of the site-specific field evaluations and analyses described above. Several general design guidelines are described below based on the

physical characteristics of existing off-channel habitats and habitat relationships of the target species and life stages. To ensure year-round flow and suitable water depths for extended juvenile rearing, off-channel areas should be excavated to a depth of approximately 1 m below the lowest level of the summer water table. An important objective would be to mimic the channel geometry, dimensions, and gradient of existing groundwater channels within the site or other sites where suitable habitat has been documented. Based on field observations, channel gradient does not appear to be a major determinant of habitat quality in groundwater channels; rather, habitat quality appears to be mainly a function of channel depth, riparian cover, and river-floodplain connectivity.

The presence of existing riparian vegetation is a key component of the off-channel habitat design because of its role in promoting scour, enhancing habitat quality, and creating river-floodplain connectivity. While a primary design objective is to minimize dependence on artificial structures, site-specific hydraulic and channel stability assessments may identify the need for additional structural controls or hard points to serve these functions where vegetation is not present. A broad range of boulder and woody structure designs and installation methods are described in the literature. Determining the feasibility and performance of various designs would require a review of the success and failures of these designs under similar settings, as well as site-specific analyses of the hydraulic and geomorphic forces acting on these structures under typical flood flows.

L.2 Objectives and Benefits

The primary objectives of the juvenile rearing habitat expansion actions would be to improve the connectivity of existing off-channel habitats with the main river channel, and increase the quantity and quality of these habitats for extended in-river rearing of spring-run Chinook salmon. Low habitat diversity or complexity is believed to be one of the primary factors limiting production and life history diversity of juvenile salmonids in the Lower Yuba River (Lower Yuba River Fisheries Technical Group 2005). It is hypothesized that the quantity and quality of available rearing habitat limit the rearing capacity of the Lower Yuba River and the number of juveniles that can successfully rear to large sizes (>70 mm FL) before emigrating to the ocean. Limited rearing habitat in the Lower Yuba River may increase the number of Chinook salmon fry that migrate to downstream reaches (Lower Yuba River below Daguerre Point Dam, Feather River, Sacramento River, Delta) where rearing conditions may be less conducive for growth and survival. Thus, increasing the amount of habitat capable of supporting extended in-river rearing of juvenile spring-run Chinook salmon would be expected to increase opportunities for fry to complete the majority of their freshwater rearing in the Yuba River and to increase the overall survival of fry to the smolt stage.

Enhancement of existing off-channel habitats is considered a relatively simple and cost-effective action for achieving juvenile rearing habitat expansion objectives. From a geomorphic perspective, enhancement of natural floodplain habitats can be readily accomplished and has a high probability of success based on current understanding of the natural processes that create and maintain these habitats in the Lower Yuba River. From a biological perspective, these actions are expected to result in immediate and potentially long-term gains in habitat known to support extended in-river rearing of Chinook salmon, and therefore addresses an important limiting factor that has been identified for spring-run Chinook salmon in the Lower Yuba River.

L.3 Estimated Cost

L.3.1 Capital Cost

For the purposes of cost estimation, it was assumed that the newly excavated channels would be trapezoidal in cross section, with top widths of 10 m, bottom widths of 4 m, bank slopes of 1.5 horizontal to 1 vertical, and channel gradients up to 0.5 percent.

The pre-feasibility study capital cost estimate for implementing the juvenile rearing habitat expansion actions, including permitting, design, and construction, is approximately $1.3 million. Construction costs for the action would depend in large part on the amount of gravel excavation necessary to construct side channels and restore functional floodplain habitat.

L.3.2 Operations and Maintenance

The cost of maintaining the juvenile rearing habitat component of the Lower Yuba River Actions is estimated to be $30,000 per year and $1.5 million for 50 years.

L.3.3 Funding Partners

The USFWS AFRP has funded SYRCL for a total of $160,000 for a pilot restoration project intended to inform planning, design, and permitting for a more extensive juvenile rearing habitat project (Campbell pers. comm.). In addition, AFRP has identified funding for ongoing Yuba River salmon habitat evaluation and restoration, some of which might be available for portions of project construction or maintenance. Western Aggregates has pledged to commit $50,000 toward implementation of floodplain restoration on property they own in the area and where they have agreed to establish a 180-acre conservation easement.

L.4 Implementation Schedule

Members of the RMT have suggested (Appendix M in the Final HEP) that, because several tools are already in development and the pilot restoration project design is currently underway, (1) preliminary design and permitting analysis for the juvenile rearing habitat expansion actions could be completed within 1 year; (2) permitting, landowner access, and other issues could be resolved within 1 or 2 years; and (3) construction could be accomplished in one to two seasons.

L.5 Other Issues

Channel design would be coordinated with the SYRCL plans, AFRP-related planning or funded actions, and Western Aggregates floodplain restoration. Because designs for the juvenile rearing habitat expansion actions are still conceptual in nature, constraints and challenges to completing the action may not have been fully identified. Permits and landowner permission would need to be obtained for construction at each of the restoration sites.

L.6 References

L.6.1 Printed References

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Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18: 487-521.

L.6.2 Personal Communication

Campbell, E. Habitat Restoration Coordinator. U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program. Stockton, CA. Telephone conversation with Chris Wilkinson, California Department of Water Resources, regarding juvenile salmonid rearing habitat restoration in the lower Yuba River. October 27, 2009.

Mitchell, Bill. Fisheries Biologist. ICF International. Sacramento, CA. Meeting with the HEA Steering Committee regarding juvenile rearing habitat expansion sites in the lower Yuba River. October 14, 2010.