Appendix 5.H
Aquatic Construction and Maintenance Effects

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5.H.0 Executive Summary

Construction and maintenance activities associated with several conservation measures included in the Bay Delta Conservation Plan (BDCP) covered activities have the potential to cause adverse effects on covered fish species. The specific conservation measures and the types of effects they may have on covered fish species are listed in Table 5.H.0-1. Analysis of these potential effects was conducted based on engineering data developed to date, assumptions made based on monitoring data for similar projects, and assumptions made about restoration design. All of these effects are temporary and localized to the area of construction or maintenance, and none are expected to result in any substantial adverse effects on the covered fish species (Table 5.H.0-2). The following section summarizes conclusions of construction and maintenance effects.

Table 5.H.0-1. Conservation Measures that May Result in Construction- and Maintenance-Related Effects

CM	Title/Description	Construction and Maintenance Elements (Aquatic Only)
1	Water Facilities and Operation	• Clearing and grubbing/demolition on the riverbank at each of the three intake locations • Detour and levee reinforcement on the riverbank at each of the three intake locations • Setback levee on the riverbank at each of the three intake locations • Installation of sheet-pile wall cofferdams at the three intake locations on the riverbank and in the river channel • Dewatering of completed cofferdams, if possible • Excavation and dredging at each of the three intake locations on the riverbank and in the river channel after the cofferdam is constructed • Installation of foundation piles for each of the three intakes inside completed cofferdams • Armor and restoration of shorelines at each of the three intake locations after the cofferdam is constructed • Clearing and grubbing at the six barge landings (most likely limited to any riparian areas in the path of equipment used to construct the landings, and access for equipment, onloading and offloading supplies from the landings), pile driving, construction of the dock on top of the piles, and ultimately dismantling of the dock and cutting off the piles • Construction of the north Delta intakes is expected to begin about 2 years after BDCP authorization and continue for 9–10 years
2	Yolo Bypass Fisheries Enhancement	• Physical modifications to Fremont Weir and Yolo Bypass (e.g., new/modified fish ladders, new gated seasonal floodplain channel) • Fish screens at Yolo diversions • New/replaced Tule Canal and toe drain impoundment structures and agricultural crossings • Lisbon Weir improvements (e.g., fish gate) • Lower and upper Putah Creek improvements (e.g., realignments) • Fish barriers at Knights Landing Ridge Cut and Colusa Basin Drain • Physical and nonphysical barriers in Sacramento River (e.g., bubble curtains or log booms)

CM	Title/Description	Construction and Maintenance Elements (Aquatic Only)
3	Natural Communities Protection and Restoration	• Levee improvements • Removal of berms, levees, etc., and construction of berms, levees, reworking of agricultural, delivery channels, etc. • Sacramento Weir Improvements (could include a channel from Sacramento River to Sacramento Weir and from Sacramento Weir to Toe Drain) • The above modifications will be initiated by year 11 and operational by year 13
4	Tidal Natural Communities Restoration	• Restore natural remnant meander tidal channels • Excavate channels to allow establishment of sinuous, high-density, dendritic network • Modify ditches, cuts, and levees to encourage more natural tidal circulation • Recontour surface elevations to maximize tidal marsh creation prior to levee breaching • Cultivate stands of tules through flood irrigation prior to levee breaching • Restoration of the first 4,000 acres, immediately after BDCP authorization (65,000 acres total)
5	Seasonally Inundated Floodplain Restoration	• Set back, remove, and/or breach levees • Remove riprap and bank protection between setback levees • Modify channels • Create floodway bypasses • At least 1,000 acres restored by year 15 years, and increments of 1,800 acres for each 5-year time period until year 40 (10,000 acres total)
6	Channel Margin Enhancement	• Remove riprap from channel margins • Modify or set back levees • Install large woody material in levees • About 5 miles of channel margin enhancement by each of years 10, 20, 25, and 30 (20 miles total)
7	Riparian Natural Community Restoration	• Remove riprap • Modify levees and/or channel modification, including possible bench construction • Install riparian plantings • Riparian restoration will be a component of CM4, CM5, CM6 projects
9	Vernal Pool and Alkali Seasonal Wetland Complex Restoration	• Excavate or recontour historical vernal pools; because vernal pools typically have no outlets to receiving waters used by covered fish, this conservation measure will not result in any effects on covered fish • Most restoration actions likely implemented by year 15
10	Nontidal Marsh Restoration	• Establish connectivity with existing water conveyance system • Grade to create wetland topography • Completed by year 10
12	Methylmercury Management	• Provide site-specific characterization and monitoring to mitigate methylmercury production during construction and operations • This conservation measure does not result in construction; therefore, will not result in any construction effects on covered fish; however, methylmercury and this conservation measure are discussed in the context of potentially disturbing sediment containing methylmercury during construction
14	Stockton Deep Water Ship Channel Dissolved Oxygen Levels	• Possible construction of additional aeration facilities • Provide funding for the continued long-term operation and maintenance of an aeration facility by year 1

CM	Title/Description	Construction and Maintenance Elements (Aquatic Only)
15	Localized Reduction of Predatory Fishes	• Removal of unused predator-housing structures (e.g., old piers, abandoned boats) • Predator reduction efforts will begin by year 3 and continue throughout the BDCP term
16	Nonphysical Fish Barriers	• Install nonphysical fish barriers (e.g., sounds, light, bubbles) • Delta Cross Channel and Georgiana Slough barriers expected by year 4
18	Conservation Hatcheries	• Possible bank and channel construction • Hatcheries expanded or constructed by years 4 and 7, respectively
19	Urban Stormwater Treatment	• Establish vegetative buffer strips • Construct bioretention systems • Program operational by about year 3
21	Nonproject Diversions	• Removal/relocation of unscreened diversions • Consolidation of existing smaller unscreened diversions into one larger screened diversion • Program operational by about year 3, with individual actions requiring 4 to 8 years each to design, permit, and construct
22	Avoidance and Minimization Measures	• This conservation measure is intended to minimize and avoid effects related to the other conservation measures and will not result in any additional effects
CM = Conservation Measure.		

5.H.0.1 CM1 Water Facilities and Operation

Construction of the new intake facilities will result in localized, temporary increases in turbidity and associated suspended sediments that may contain contaminants, but those increases will be minimized through standard monitoring and sediment control measures. Additionally, as with any construction activities, there is potential for accidental spills of fuels and lubricants. All of these effects will be monitored and controlled during construction by BDCP minimization measures and permit requirements.

Cofferdam installation at the intakes and pile driving at the barge landings will disturb bottom sediments and could result in temporary turbidity levels that could affect covered fish species. In-water construction activities that could generate increased turbidity are not continuous. Sheet pile driving for the cofferdams typically will occur during an approximately 8-hour period each day for about 5 months (during the in-water work window of June through October). In-water work associated with constructing the barge landings could take several weeks but also will be confined to a typical 8-hour work day.

Of the urban-related toxic constituents identified in Appendix 5.D, *Contaminants*, metals (lead and copper), hydrocarbons, organochlorine pesticides, and polychlorinated biphenyls (PCBs) are common urban contaminants with the greatest affinity for sediments and potentially could be present in sediments that will be disturbed during installation of the cofferdams. In addition, mercury is present in the Sacramento River and could be sequestered in bottom sediments. The barge landings will be constructed on smaller waterways and are more likely to have agriculture-related toxins, including copper and organochlorine pesticides.

Sediment disturbance caused by in-water construction may cause localized and temporary turbidity and the suspension of potentially contaminated sediments. These effects will be minimized by installing in-river cofferdams to isolate most other subsequent construction activities from the water. In addition, the implementation of the measures described in Appendix 3.C, *Avoidance and Minimization Measures*, such as: Avoidance and Minimization Measure (AMM) 3 *Stormwater Pollution Prevention* Plan (SWPPP), *AMM4 Erosion and Sediment Control Plan*, *AMM7 Barge Operations Plan*, and *AMM2 Construction Best Management Practices and Monitoring* will minimize the potential for turbidity and sediment resuspension in surface waters.

The measures described in *CM22 Avoidance and Minimization Measures* were developed to ensure compliance with expected requirements of local permits, clearances, and National Pollutant Discharge Elimination System (NPDES) permits or other waste discharge requirements (WDRs) from the Regional Water Quality Control Board (Regional Water Board). *CM22 Avoidance and Minimization Measures* also includes implementation of appropriate best management practices (BMPs) to protect water resources from contamination.

Additionally, as with any construction activity, accidental spills may occur, but implementation of *CM22 Avoidance and Minimization Measures* will reduce the potential for introduction of contaminants to surface waters and provide for effective containment and cleanup should accidental spills occur. These commitments include: *AMM5 Spill Prevention, Containment, and Countermeasure Plan; AMM1 Worker Awareness Training*; and *AMM2 Construction Best Management Practices and Monitoring.* In addition, the majority of the in-water construction work will be isolated from the river environment by installing cofferdams around the intake sites.

Construction at the intake and barge landing sites requires in-water pile driving. If piles are driven with a vibratory driver, adverse effects on fish from underwater sound exposure will be avoided. If impact pile driving is needed, potentially injurious sound levels will be localized (up to 3,280 feet from the pile driving location), temporary (up to 30% of work days during the 5-month in-water construction period, from June through October), and intermittent (up to about 150 minutes spread over a period of 8 daylight work hours per day). The in-water work window is established so that potentially injurious activities are likely to occur when most covered fish species are absent or only present at low densities. However, certain covered fish species potentially could be present during the in-water work window and during pile driving activities. Thus, impact pile driving potentially could affect the covered species, including low numbers of migrating adults and rearing juvenile Chinook salmon, steelhead, sturgeon, and lamprey, as well as other noncovered fish species that serve as prey for these covered species.

To the extent possible, the cofferdams necessary for the intake construction will be installed using a vibratory pile driver, which is not likely to cause physical injury to covered fish species. However, the geologic conditions at each intake site determine the type of pile driver needed. Impact pile driving may be required if hard substrate is encountered, which generates underwater sound levels that exceed injury and harm thresholds for fish, as opposed to vibratory pile driving. At other locations along the Sacramento River (e.g., Freeport intake location north of the proposed north Delta intake sites), the geologic conditions permitted vibratory pile driving approximately 70% of the time, but hard substrate required impact pile driving approximately 30% of the time. Assuming a maximum installation of 12 piles per day and 700 hammer strikes per pile where an impact hammer is required, this equates to a maximum duration of impact hammer operation of approximately 150 minutes on any given work day at each intake location. Pile driving operations typically will be restricted to an 8-hour, daylight-only work period.

On those days when impact pile driving occurs, there could be periods of time when the underwater sound levels exceed injury and harm thresholds used by the National Marine Fisheries Service. Sound levels exceeding adverse effect thresholds will extend outward from the pile driving locations up to 3,280 feet, as bounded by channel configuration at each site (injurious sound levels are not transmitted around river bends).

Because of the timing of in-water construction (June through October), most covered species life stages are not present in the areas affected by elevated sound levels from pile driving activities. The habitat at the intake sites is of relatively poor condition, with steep riprap armored banks and limited in-water or overwater habitat features typically associated with rearing habitat. As a result, these river reaches are expected to be used primarily as migratory corridors. For most species with migratory life stages that have the potential to be present, only a small portion of the population is expected to be exposed to the increased underwater sound levels because these increases generally would occur at the end or beginning of peak migration periods. The upstream adult migration of several covered fish may coincide with these in-water pile driving activities, including green and white sturgeon, fall-run Chinook salmon, spring-run Chinook salmon, steelhead, and lamprey. Likewise, late juvenile outmigrating salmonids and delta smelt adults, eggs, and larvae may be present in June or July, and juvenile sturgeon and lamprey may be present throughout the typical June through October in-water work window. Adult and juvenile Chinook salmon, sturgeon, splittail, and lamprey may be able to move away from the area affected by the underwater sound. If pile driving occurs, the sound generated at each intake location would be intermittent over a period of 8 hours each day. Effects on covered fish species are likely to be low to moderate, depending on the duration of exposure and the actual need for impact driving (vs. vibratory driving).

In addition to the in-water pile driving activities, pile driving will occur inside the completed cofferdams to construct the intakes. Because of the number of these piles, this work will need to occur throughout the year and will have the potential to affect covered species occurring in the area. However, working inside a dewatered cofferdam is expected to reduce the intensity of the sound levels transmitted to the water. While such reductions are highly variable, a conservative 10-decibel (dB) reduction estimate is assumed (Thorson and Reyff 2004; California Department of Transportation 2009, 2010; Illinworth & Rodkin, Inc. 2007). If a cofferdam cannot be effectively or completely dewatered, a bubble curtain (or other comparable device) will be used to obtain a similar 10 dB sound reduction. Achieving this level of sound reduction will maintain the peak sound pressure levels below the single-strike injury threshold. Therefore, potential effects on fish will be based on the cumulative sound exposure from multiple pile strikes. The 10 dB sound level reductions will also limit the range where the cumulative sound exposure thresholds may be exceeded, although this range is also affected by the number of pile strikes that a fish would be exposed to during any given day.

Assuming an additional attenuation rate of 4.5 dB per doubling of distance, the maximum distance within which the cumulative effects threshold criteria would likely be exceeded is about 136 meters (about 450 feet) from the impact pile driving locations. As this distance is shorter than the estimated width of the river at the three intake sites (between about 535 and 645 feet wide), potentially harmful cumulative underwater sound levels would not extend across the entire river. Therefore, some refuge areas would be present along the opposite shoreline, with the size of the refuge area dependent on the actual number of impact pile strikes occurring during a particular work day. The size of the refuge area will be larger if fewer strikes occur in a day, and smaller if more strikes occur.

While pile driving at the barge landing sites will occur during the approved in-water construction window, an attenuation device (e.g., isolation casing, bubble curtain) typically will be used to reduce the underwater sound levels. As described above, a 10 dB reduction is expected to be achievable with these devices. However, the water channels at these sites are less than 450 feet wide, resulting in little or no refuge areas for fish to avoid potential sound level effects, under the same pile driving conditions as described above.

Except for splittail and delta smelt, no spawning occurs in this area, so no egg or fry life stages of Chinook salmon or steelhead would be affected, and no egg or larvae life stages of sturgeon or lamprey would be affected. Few delta smelt or splittail adults would be expected in the vicinity of the intake construction because it is not their primary habitat area. Overall, there could be instances of take and/or disruption of behavior or migration during intake construction, but underwater noise thresholds would be exceeded when the fewest fish, and therefore the lowest potential for effects, would occur.

Construction of the new intake facilities may result in a permanent impact of up to about 2.6 total miles of low-value channel margin habitat and up to 5.1 total acres of open-water area, likely used primarily as migratory habitat, although some limited rearing also may occur. These areas also may provide some limited spawning habitat for some species. Project construction may result in the temporary loss of up to 7.5 total acres of open-water habitat. These permanent and temporary impacts will occur in three roughly even patches on one side of the river, at each intake location. These temporary and permanent habitat impacts will be offset by the BDCP restoration efforts listed in Table 5.H.0-1.

The affected habitat associated with the intake facilities currently is armored levee bank with limited riparian vegetation of generally low-value for species rearing. The armored banks prevent wood from accumulating and providing habitat complexity that is typical of unarmored banks. Although some vegetation grows along the banks at the intake sites, about 98% of the shoreline has less than 25% overhead cover (primarily from overhanging vegetation), and about 23% of the shoreline has less than 5% overhead cover. These low–overhead cover densities result in limited shade or organic input. There are no side channels, floodplain connections, or mechanisms for such off-channel habitat to develop in these areas. In addition, the slopes of the existing banks are typically steep at the intake locations. As discussed in Appendix 5.E, *Habitat Restoration*, the current conditions at the intake sites are representative of the habitats with the lowest use by juvenile salmon (steep bank, riprap, low density of large woody debris) and most other covered species.

At each intake, between 1.6 and 3.1 acres of river area will be located behind the cofferdam and temporarily or permanently lost. During the in-water construction period, a total of up to about 19.6 acres of in-water habitat would be affected by construction and dredging activities. These effects are likely to result in the loss of low-value spawning, rearing, and migration habitat for covered fish species. Likewise, the footprint of each intake and transition wall structures would result in permanent loss of between about 1,560 and 2,400 feet of primarily steep-banked, riprapped habitat at each intake, totaling up to about 2.6 miles of shoreline and 5.1 acres of in-water habitat.

Habitat restoration completed under the BDCP conservation measures will occur at various times throughout the life of the project. *CM4 Tidal Natural Communities Restoration* will provide substantially more rearing and spawning habitat for delta smelt and Sacramento splittail by restoring 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. This restoration will be implemented incrementally, with the first 4,000 acres restored immediately after BDCP authorization. Similarly, *CM6 Channel Margin Enhancement* also will be phased in over a number of years, with 5 miles of enhancement completed by year 10 and an additional 5 miles completed by each of years 20, 25, and 30, for a total of 20 miles of enhancement. Channel margin enhancement is intended to improve habitat function in the north Delta, along important fish migratory and rearing routes. *CM7 Riparian Natural Community Restoration* actions also will occur over time, with 2,300 acres restored by year 15 and 5,000 (cumulative) acres restored by year 40.

Construction of the head of Old River operable gate includes placement of sheetpiles and riprap, which could directly injure covered fish species in the vicinity, and dredging activities, which could entrain and injure fish.

Cofferdams, if used, would be installed to isolate gate construction areas from the channel. Although vibratory pile driving would be the primary method for installing the cofferdams, some impact pile driving may be required. The potential effect of underwater sound levels generated by impact pile driving, would be the same as those described for pile driving at the north Delta intake locations.

Placement of cofferdams in the channels could also trap fish, which could be killed during dewatering of the construction area and other construction activities. Direct injury associated with construction and maintenance activities, including dredging, would have a less-than-significant impact on the covered species, because the number of fish injured would likely be small, due to adherence with in-water work window, environmental commitments, and BMPs described in Appendix 3.C, *Avoidance and Minimization Measures*. Construction activities would remove, disturb, modify, and replace channel-bottom and channel-bank substrates, although this area would be similar to the existing footprint of the temporary barriers, with previously modified shallow-water habitat.

Construction of the operable gate would take approximately 2 years, with cofferdams used primarily in the first year, and limited activities to remove the cofferdams in the subsequent year.

5.H.0.2 Other Conservation Measures

Other aquatic-related conservation measures include *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, *CM15 Localized Reduction of Predatory Fishes*, and *CM16 Nonphysical Fish Barriers*. These measures likely will cause only temporary, localized, and minor noise and turbidity effects and the potential for accidental spills at each specific site. Such effects will be similar to, but of a much smaller magnitude than, those described for construction of the intakes (*CM1 Water Facilities and Operation*). These other conservation measures also rely on the implementation of *CM22 Avoidance and Minimization Measures* to minimize the potential to affect covered fish species.

Similar to the intake construction, activities associated with *CM2 Yolo Bypass Fisheries Enhancement*, *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, *CM7 Riparian Natural Community Restoration*, *CM10 Nontidal Marsh Restoration*, *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, *CM15 Localized Reduction of Predatory Fishes*, *CM16 Nonphysical Fish Barriers*, and *CM21 Nonproject Diversions* will be limited to periods of lowest fish density and include implementation of minimization measures described in *CM22 Avoidance and Minimization Measures*.

Underwater noise associated with in-water construction for these conservation measures is not expected to be as high as that estimated for the new intakes, primarily because vibratory hammers are expected to be used for construction of these smaller structures (e.g., nonphysical barriers and intake screens) when pile driving is necessary, which is not expected to result in adverse effects on fish. Similarly, removal of in-water structures will be conducted using a vibratory hammer or crane on a barge. Other in-water construction activities, such as dredging, also are not expected to exceed underwater sound thresholds.

The magnitude of water quality effects on covered fish from turbidity and associated suspended sediments and from accidental spills also would likely be of lower magnitude than that described for the intakes, and would likely be minimal overall because of the very temporary and localized nature of the activities and the timing of activities outside periods of high fish density. Accidental spills, turbidity, and other water quality effects will be minimized through implementation of *CM22 Avoidance and Minimization Measures*, as well as by requirements of the permits necessary to construct these facilities. These measures include: *AMM3 Stormwater Pollution Prevention Plan*; *AMM4 Erosion and Sediment Control Plan*; *AMM5 Spill Prevention, Containment, and Countermeasure Plan; AMM7 Barge Operations Plan*; *AMM1 Worker Awareness Training*; and *AMM2 Construction Best Management Practices and Monitoring.*

Restoration construction and activities associated with nonphysical barriers, removal of in-water structures, and installing intake screening have the potential to permanently or temporarily remove or disturb aquatic habitats as a result of levee breaching or other activities that directly or indirectly (e.g., bank scour) result in the loss of habitat. However, this removal or temporary disturbance is expected to be small, highly localized, and fully offset by the benefits provided by the conservation measures.

The restoration, intake screening, in-water structure removal, and nonphysical barriers may result in very minor loss or changes in habitat, with exact amounts depending on the specific areas and design of the conservation measures. For the most part, these activities will be located in areas that avoid or minimize effects on sensitive habitats to the extent possible. Tidal marsh restoration included in *CM4 Tidal Natural Communities Restoration* will provide substantially more rearing and spawning habitat for some covered fish, which will more than offset the potential temporary and minor changes in habitat resulting from construction of these conservation measures.

Periodic maintenance of the intake facilities, other in-water and overwater structures, and at the restoration sites has the potential to temporarily increase localized noise in the vicinity of the intakes and structures; except during emergencies, maintenance can be planned to avoid periods of high fish densities.

No maintenance activities are expected to use an impact pile driver, and, therefore, underwater noise is expected to be minimal. Similarly, minimal sediment disturbance is anticipated. As with all in-water construction activities, there is potential for accidental spills, but that potential will be minimized through measures described in *CM22 Avoidance and Minimization Measures*. These activities also will be timed to avoid periods of high fish densities, except during emergencies.

In-water construction and maintenance activities have the potential to directly harm or kill individual fish, but *CM22 Avoidance and Minimization Measures*, including timing activities to periods of lowest fish density, will be implemented to minimize this effect to the extent possible; emergency maintenance may require in-water activities during periods of high fish density.

All in-water work activities have the potential to directly harm or kill individual fish in the vicinity of the construction activities, but no major effects on species are expected from these activities, with the implementation *CM22 Avoidance and Minimization Measures*. Overall, construction and maintenance associated with the BDCP covered activities will be spread throughout the Plan Area and will occur primarily during periods of low fish density and over the BDCP implementation period (50 years). *CM22 Avoidance and Minimization Measures* will minimize and avoid many potential effects, and other conservation measures will enhance existing habitat conditions, including *CM2 Yolo Bypass Fisheries Enhancement*, *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration.* These conservation measures include restoration and other operational improvements to provide alternative habitats and areas of refuge from construction activities. Except for during emergencies, direct effects on individuals during construction or maintenance are expected to be minimized by the implementation of *CM22 Avoidance and Minimization Measures* and the *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (Basin Plan).

Table 5.H.0-2. Potential for Effects of Construction and Maintenance Activities on Covered Fish Species

		BDCP Subregions								
Species	**Life Stage**	**Yolo Bypass**	**Cache Slough**	**North Delta**	**West Delta**	**Suisun Bay**	**Suisun Marsh**	**East Delta**	**South Delta**	**Total Effects**
Delta smelt	Egg	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM	RC, RM	RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Larva	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Juvenile	RC, RM	RC, RM, OCC, OCM		RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM			FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
Longfin smelt	Egg	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Larva	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Juvenile					RC, RM, OCC, OCM	RC, RM, OCC, OCM			FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
Steelhead	Egg/Embryo									
	Fry									
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC*, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC*, FM, OCC, OCM, RC, RM	FC*, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
Winter-run Chinook salmon	Egg/Embryo									
	Fry	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM					FC, FM, OCC, OCM, RC, RM
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM

Species	Life Stage	BDCP Subregions								Total Effects
		Yolo Bypass	Cache Slough	North Delta	West Delta	Suisun Bay	Suisun Marsh	East Delta	South Delta	
Spring-run Chinook salmon	Egg/Embryo									
	Fry									
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM			FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM			FC, FM, OCC, OCM, RC, RM
Fall-/late fall–run Chinook salmon	Egg/Embryo									
	Fry	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
Late fall–run Chinook salmon	Egg/Embryo									
	Fry									
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM			FC, FM, OCC, OCM, RC, RM
Sacramento splittail	Egg/Embryo	RC, RM	RC, RM	FC, FM, OCC, OCM, RC, RM	RC, RM		RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Larvae	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM

Species	Life Stage	BDCP Subregions								Total Effects
		Yolo Bypass	Cache Slough	North Delta	West Delta	Suisun Bay	Suisun Marsh	East Delta	South Delta	
White sturgeon	Egg/Embryo									
	Larva	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
Green sturgeon	Egg/Embryo									
	Larva									
	Juvenile	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
Pacific lamprey	Egg/Embryo									
	Ammocoete	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM			FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM
	Macropthalmia	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
River lamprey	Egg/Embryo									
	Ammocoete	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM			FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM
	Macropthalmia	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM
	Adult	RC, RM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	RC, RM, OCC, OCM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM	FC, FM, OCC, OCM, RC, RM

		BDCP Subregions								
Species	**Life Stage**	**Yolo Bypass**	**Cache Slough**	**North Delta**	**West Delta**	**Suisun Bay**	**Suisun Marsh**	**East Delta**	**South Delta**	**Total Effects**
Categories of effects as a result of BDCP implementation: FC = facility construction; FM = facility maintenance; RC = restoration construction; RM = restoration maintenance; OCC = other conservation measures construction; OCM = other conservation measures maintenance. * Underwater sound generated by impact pile driving is resulting in the moderate effect.										
Potential for Effects:										
None	None: Covered fish species are not present in area of effects of construction and maintenance activities.									
Low	Low: Covered fish species are present in area of effects of construction and maintenance activities but have low abundance of species/life stage in the area, and no or low effects on covered fish species are identified.									
Medium	Medium: Covered fish species are present in area of effects of construction and maintenance activities but have a moderate abundance of species/life stage in the area, and potential for effect is deemed to be moderate.									
High	High: Covered fish species are present in area of effects of construction and maintenance activities, and potential for effect is deemed to be high.									
Note: Uncertainty is not included in the potential of effect, as it has been determined that the uncertainty is not sufficient to indicate elevated effects.										

Appendix 5.H
Aquatic Construction and Maintenance Effects

Contents

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Acronyms and Abbreviations

BDCP	Bay Delta Conservation Plan
Caltrans	California Department of Transportation
CIDH	cast-in-drilled-hole
CM	conservation measure
cm	centimeter
dB	decibels
DO	dissolved oxygen
DPS	distinct population segment
DWR	California Department of Water Resources
LED	light-emitting diode
MCY	million cubic-yards
MIL	modulated intense light
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination Service
NTU	nephelometric turbidity unit
RM	river mile
RMS	root mean squared
ROA	restoration opportunity area
RWQCB	Regional Water Quality Control Board
SAV	submerged aquatic vegetation
SEL	sound exposure level
$SEL_{cumulative}$	cumulative sound exposure level
SR	State Route
SWPPP	stormwater pollution prevention plan
Basin Plan	Water Quality Control Plan for the Sacramento and San Joaquin River Basins
WDR	waste discharge requirement

Appendix 5.H
Aquatic Construction and Maintenance Effects

5.H.1 Organization of Appendix

This appendix provides details of technical analyses of effects of restoration on covered fish species under the Bay Delta Conservation Plan (BDCP). The appendix is organized as follows.

- **Section 5.H.2, *Introduction*,** provides a summary of the different construction activities associated with each conservation measure, stressors, and potential effects.
- **Section 5.H.3, *Information on Covered Fish Species*,** describes fish species anticipated to occur in different BDCP areas throughout the year and the habitat those species use.
- **Section 5.H.4, *Construction and Maintenance Activities*,** describes the phasing, timing, and activities anticipated under each conservation measure.
- **Section 5.H.5, *Methods Used to Evaluate Potential Construction and Maintenance Effects on Covered Fish Species*,** outlines the methods used to assess the effects of the stressors associated with construction and maintenance on the covered fish species.
- **Section 5.H.6, *Results of Analysis of Construction Effects on Covered Fish Species*,** identifies the effects on covered fish species by life stage and region associated with construction activities for each conservation measure.
- **Section 5.H.7, *Maintenance-Related Effects*,** identifies the effects on covered fish species by life stage and region associated with construction activities for each conservation measure.
- **Section 5.H.8, *Conclusions*,** summarizes the overall results of the construction and maintenance effect analyses.

5.H.2 Introduction

This appendix analyzes the potential effects on the aquatic environment and covered fish species associated with proposed construction and maintenance activities (for effects of construction and maintenance activities on covered terrestrial species and natural communities, see Chapter 5, *Effects Analysis*). The conservation measures and the construction and maintenance elements of these measures are listed in Table 5.H.2-1. Although there are various types of structures and construction activities associated with the different conservation measures, the construction and maintenance activities can be grouped by a few potential effects, as shown in Table 5.H.2-1.

The construction and maintenance activities described here are limited to those that have the potential to affect the aquatic environment and covered fish species. While the construction and maintenance activities for all of the conservation measures are extensive, the activities will be spread throughout the Plan Area and over the implementation period (50 years) of the BDCP. However, most of the conservation measure construction activities will begin by years 5 to 10, with the intent of meeting most species response goals and objectives by year 15. The extended implementation schedule is based on the time required to acquire lands for restoration, develop site specific plans, obtain regulatory approval/permits, and conduct construction activities. It is assumed that some of the initial restoration activities will occur on public land, facilitating quicker implementation, while the subsequent restoration of private lands will take longer to implement because of the land acquisition process. As described in more detail below, most of the construction- and maintenance-related impacts of the north Delta intakes (Conservation Measure [CM] 1 *Water Facilities and Operation*), restoration (*CM2 Yolo Bypass Fisheries Enhancement*, *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration*), and other conservation measures are expected to be localized and occur over a relatively short period of time, because impacts will be associated with discrete activities at specific sites.

The north Delta diversion facilities also will require a sequential implementation schedule. Therefore, a number of the conservation measure identified in Table 5.H.2-1 will be initiated before construction-related effects occur and continue to be implemented well past the construction period. Monitoring and adaptive management will provide opportunities to assess the effectiveness of the implemented conservation measures and allow potential adjustments to the implementation of subsequent conservation measures to facilitate achieving the BDCP biological goals and objectives.

Table 5.H.2-1. Main Construction Elements of BDCP Conservation Measures with Potential to Affect Aquatic Environments (details of these measures provided in Chapter 3)

CM	Title/Description	Construction Elements (Aquatic Only)	Area/Subregion
1	Water Facilities and Operation	• Clearing and grubbing/demolition on the riverbank at each of the three intake locations • Detour and levee reinforcement on the riverbank at each of the three intake locations • Setback levee on the riverbank at each of the three intake locations • Installing sheet-pile wall cofferdams at each of the three intake locations on the riverbank and in the river channel • Dewatering of the cofferdams, where feasible • Excavating and dredging at each of the three intake locations on the riverbank and in the river channel after the cofferdam is constructed • Installing foundation piles for each of the three intakes after the cofferdam is constructed • Armoring and restoring the shoreline at each of the three intake locations after the cofferdam is constructed • Clearing and grubbing at the six barge landings (most likely limited to any riparian areas in the path of equipment used to construct the landings, and access for equipment, onloading and offloading supplies from the landings), pile driving, construction of the dock on top of the piles, and ultimately dismantling of the dock and cutting off the piles • Construction of north Delta intakes is expected to begin about 2 years after permit issuance and continue for 9–10 years	North Delta South Delta East Delta

CM	Title/Description	Construction Elements (Aquatic Only)	Area/Subregion
2	Yolo Bypass Fisheries Enhancement	• Physical modifications to Fremont Weir and Yolo Bypass (e.g., new/modified fish ladders, new gated seasonal floodplain channel) • Fish screens at Yolo diversions • New/replaced Tule Canal and toe drain impoundment structures and agricultural crossings • Lisbon Weir improvements (e.g., fish gate) • Lower and upper Putah Creek improvements (e.g., realignments) • Fish barriers at Knights Landing Ridge Cut and Colusa Basin Drain • Physical and nonphysical barriers in Sacramento River (e.g., bubble curtains or log booms) • Levee improvements • Removal of berms, levees, etc., and construction of berms, levees, reworking of agricultural, delivery channels, etc. • Sacramento Weir Improvements (could include a channel from Sacramento River to Sacramento Weir and from Sacramento Weir to Toe Drain) • The above modifications will be initiated by year 11 and operations by year 13	Yolo Bypass
3	Natural Communities Protection and Restoration	• This conservation measure will not result in any construction effects on covered fish because there will be no construction associated with it	NA
4	Tidal Natural Communities Restoration	• Restore natural remnant meander tidal channels • Excavate channels to allow establishment of sinuous, high-density, dendritic network • Modify ditches, cuts, and levees to encourage more natural tidal circulation • Recontour surface elevations to maximize tidal marsh creation prior to levee breaching • Cultivate stands of tules through flood irrigation prior to levee breaching • Restoration of the first 4,000 acres immediately after BDCP authorization (65,000 acres total)	Suisun Marsh Cache Slough East Delta West Delta South Delta
5	Seasonally Inundated Floodplain Restoration	• Set back, remove, and/or breach levees • Remove riprap and bank protection between setback levees • Modify channels • Create floodway bypasses • At least 1,000 acres restored by year 15, and increments of 1,800 acres for each 5-year time period until year 40 (10,000 acres total)	Southern Delta
6	Channel Margin Enhancement	• Remove riprap from channel margins • Modify or set back levees • Install large woody material in levees • About 5 miles of channel margin enhancement by each of years 10, 20, 25, and 30 (20 miles total)	North Delta East Delta South Delta

CM	Title/Description	Construction Elements (Aquatic Only)	Area/Subregion
7	Riparian Natural Community Restoration	• Remove riprap • Modify levees and/or channel modification, including possible bench construction • Install riparian plantings • Riparian restoration also will be a component CM4, CM5, CM6 projects	North Delta East Delta South Delta
8	Grassland Natural Community Restoration	• This conservation measure will not result in any effects on covered fish because there will be no effects on or in the aquatic habitat • Restoration actions implemented between years 3 and 30	NA
9	Vernal Pool and Alkali Seasonal Wetland Complex Restoration	• Excavate or recontour historical vernal pools; because vernal pools typically have no outlets to receiving waters used by covered fish, this conservation measure will not result in any effects on covered fish • Most restoration actions likely implemented in the first 15 years	Yolo Bypass Cache Slough Suisun Marsh Suisun Bay South Delta
10	Nontidal Marsh Restoration	• Establish connectivity with existing water conveyance system • Grade to create wetland topography • Completed by year 10	Yolo Bypass North Delta
11	Natural Communities Enhancement and Management	• This conservation measure will not result in any effects on covered fish because there will be no effects on or in the aquatic habitat	NA
12	Methylmercury Management	• Provide site-specific characterization and monitoring to mitigate methylmercury production during construction and operations • This conservation measure does not result in construction; therefore, conservation measure will not result in any construction effects on covered fish; however, methylmercury and this conservation measure are discussed in the context of potentially disturbing sediment containing methylmercury during construction	Yolo Bypass Suisun Marsh Cache Slough East Delta West Delta South Delta
13	Invasive Aquatic Vegetation Control	• This conservation measure does not result in construction; therefore, conservation measure will not result in any construction effects on covered fish • Implement aquatic vegetation control by year 2	Plan Area
14	Stockton Deep Water Ship Channel Dissolved Oxygen Levels	• Possible construction of additional aeration facilities • Provide funding for the continued long-term operation and maintenance of an aeration facility by year 1	South Delta
15	Localized Reduction of Predatory Fishes	• Removal of unused predator-housing structures (e.g., old piers, abandoned boats) • Predator reduction efforts will begin by year 3 and continue throughout the permit term	North Delta South Delta East Delta
16	Nonphysical Fish Barriers	• Install nonphysical fish barriers (e.g., sounds, light, bubbles) • Delta Cross Channel and Georgiana Slough barriers expected by year 4	South Delta North Delta Yolo Bypass East Delta
17	Illegal Harvest Reduction	• This conservation measure does not result in construction; therefore, conservation measure will not result in any construction effects on covered fish • Enforcement actions expected to begin in year 3	NA

CM	Title/Description	Construction Elements (Aquatic Only)	Area/Subregion
18	Conservation Hatcheries	• Possible bank and channel construction • Hatcheries expanded or constructed by years 4 and 7, respectively	West Delta
19	Urban Stormwater Treatment	• Establish vegetative buffer strips • Construct bioretention systems • Program operational in year 3	North Delta South Delta
20	Recreational Users Invasive Species Program	• There will be no construction associated with this conservation measure; therefore, this conservation measure will not result in any effects on covered fish • Beginning in year 1	NA
21	Nonproject Diversions	• Removal/relocation of unscreened diversions • Consolidation of existing smaller unscreened diversions into one larger screened diversion • Program operational in year 3, with individual actions requiring 4 to 8 years each to design, permit, and construct	Plan Area
22	Avoidance and Minimization Measures	• This conservation measure is intended to minimize and avoid effects related to the other conservation measures and will not result in any additional effects	NA

The construction and maintenance activities associated with the conservation measures will result in similar types of potential stressors and effects on aquatic species. For example, cofferdam installation during intake construction under *CM1 Water Facilities and Operation* and levee breaching under *CM4 Tidal Natural Communities Restoration* for restoration both will result in increases in turbidity and temporary reductions in water quality, which could reduce foraging habitat for fish. However, although the type of effect may be similar, effects may differ in degree depending on location, duration, and timing. The effects on covered fish species depend on the timing of the activity and the fish present during the construction activity (as described in Section 5.H.2 and Table 5.H.2-2) and the type of construction or maintenance activity (as described in Section 5.H.3). Table 5.H.2-2 below summarizes the different types of construction activities, conservation measures, associated stressors, and potential effects on fish. These stressors and effects are discussed in detail in this appendix. Restoration actions proposed under *CM2 Yolo Bypass Fisheries Enhancement*, *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration* are described in further detail in Chapter 3 and Appendix 5.E, *Habitat Restoration*.

Construction of the conveyance facilities, forebay and reservoir by Stone Lake, and other features that are isolated from the surface waters of the Delta does not have the potential to affect the covered fish species and therefore is not discussed in this appendix.

Table 5.H.2-2. Construction and Maintenance Activities, Stressors and Potential Effects on Covered Fish Species

Construction and Maintenance Activities	CMs	Potential Stressors	Potential Effects on Fish/Fish Habitat
Construction			
Impact pile driving	1	Underwater noise	Disturbance of fish passage, fish displacement, and/or fish injury or loss
		Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Toxins from sediments	Impairment of behavior, development, growth and/or reproduction
Vibratory sheet driving or vibratory pile driving	1, 16, 21	Underwater noise	Disturbance of fish passage and/or fish displacement
		Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Toxins from sediments	Impairment of behavior, development, growth, and/or reproduction
		Increased erosion/sedimentation	Disturbance of rearing habitat
		Disturbance of benthic habitat	Decreased foraging success
Grading	2, 4, 5, 6, 7	Increased erosion/sedimentation	Impairment of spawning and/or rearing
		Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
Channel dredging/excavation	4, 5, 15	Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Resuspension of toxins attached to sediments	Impairment of behavior, development, growth, and/or reproduction
		Disturbance/removal of channel sediments	Disturbance of spawning and/or rearing habitat
			Disturbance, injury, and/or mortality of fish
		Injury or loss of benthic invertebrates	Decreased forage for benthic feeding fish

Construction and Maintenance Activities	CMs	Potential Stressors	Potential Effects on Fish/Fish Habitat
		Underwater construction activities	Mechanical injury or loss of juvenile or adult sturgeon due to dredging equipment
Refueling, operating, and storing construction equipment and materials	1, 2, 4, 5, 6, 7, 14, 15, 16, 18, 19, 21	Accidental spills or runoff of toxins	Impairment of behavior, development, growth, and/or reproduction
		Increased erosion/sedimentation	Impairment of spawning, rearing and/or migration habitat
		Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
Placement/removal of rip-rap or other bank protection	1, 4, 5, 6, 7	Increased erosion/sedimentation	Disturbance of spawning and/or rearing habitat
		Increased turbidity	Altered foraging success
			Altered predation risk
			Reduced DO
Levee breaching	4, 5	Changes in channel morphology and hydraulics	Disturbance of fish passage and/or fish displacement
			Impairment of spawning, rearing, and/or migration habitat
		Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Increased erosion/sedimentation	Disturbance of spawning and/or rearing habitat
		Changes in flow velocities	Impairment of fish passage and/or fish displacement
			Reduction in rearing habitat
Construction of levees/embankments	4, 5	Removal/destruction of cover	Reduction in habitat quantity and/or quality
		Changes in salinity	Disturbance of fish passage and/or fish displacement
			Impairment of spawning, rearing, and/or migration habitat
Use of equipment in riparian areas	1, 2, 4, 6, 7	Changes in noise, light, from physical movements of people and equipment	Disturbance of fish passage and/or fish displacement

Construction and Maintenance Activities	**CMs**	**Potential Stressors**	**Potential Effects on Fish/Fish Habitat**
Clearing, grubbing and/or demolition on riverbanks	1, 2, 4, 5, 6, 7, 14, 18, 19, 21	Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Increased erosion/sedimentation	Disturbance of spawning and/or rearing areas
		Reduced cover/shade	
		Reduced input to river of leaves, insects	Reduced rearing habitat quality
Detour and levee reinforcement and setback levees	1	Bank disturbance	Reduced spawning and/or rearing habitat quality
Installation of aeration facilities	21	Changes in channel morphology and hydraulics	Disturbance of spawning and/or rearing habitat
Removal of in-water docks, vessels, or barriers	1, 15, 16	Channel disturbance	Disturbance of spawning and/or rearing habitat
		Disturbance of benthic habitat	Decreased foraging success
Construction of dikes to maintain adjacent land uses	2, 4, 5	Increased erosion/sedimentation	Disturbance of spawning and/or rearing habitat
		Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
Installation of irrigation infrastructure and levees to control irrigation during vegetation establishment	2, 4	Increased erosion/sedimentation	Disturbance of spawning and/or rearing habitat
		Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
Maintenance			
Use of in-water equipment; water control structure maintenance or replacement; infrastructure maintenance	1, 14, 16, 18, 19, 21	Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Toxins (from sediments and spills)	Impairment of behavior, development, growth, survival, and/or reproduction
		Channel disturbance	Disturbance of spawning and/or rearing habitat
		Increased erosion/sedimentation	Disturbance of spawning and/or rearing habitat

Construction and Maintenance Activities	CMs	Potential Stressors	Potential Effects on Fish/Fish Habitat
Dredging	1, 4, 16	Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Contaminant resuspension	Impairment of growth, survival, and/or reproduction
		Disturbance and/or removal of channel sediments	Impairment of spawning and/or rearing habitat
			Disturbance, injury, and/or mortality of fish
		Disturbance of benthic habitat	Decreased foraging success
Levee maintenance (e.g., grading, breach repair, and riprap replacement)	2, 4, 5, 6, and 7	Increased turbidity*	Altered foraging success
			Altered predation risk
			Reduced DO
		Toxins (from sediments)	Impairment of growth, survival, and/or reproduction
		Increased erosion/sedimentation	Disturbance of spawning and/or rearing habitat

DO = dissolved oxygen.

* Elevated turbidity levels can have a positive or negative effect on fish, which varies by species and/or life stage, and based on a balance between protection from predators and the ability to see and capture prey (see Appendix 5.E, *Habitat Restoration,* for detailed turbidity suitability modeling results for the various covered fish species).

5.H.3 Information on Covered Fish Species

All covered fish species in the Plan Area potentially are affected by construction and maintenance activities. This section summarizes the potential spatial and temporal occurrence of these species in construction and maintenance areas during key life history events (spawning, rearing, and migration). Details on the life histories of fish species are provided in Appendix 2.A, *Species Accounts,* and summarized in Table 5.H.3-1 and Table 5.H.3-2 below.

Table 5.H.3-1. Potential Monthly Distribution of Adults and Juveniles of Non-Salmonid Fish Species in the Plan Area

Species	Distribution	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Typical in-water construction window for *CM1 Water Facilities and Operation*. Note in-water construction activities for other conservation measures are currently unknown but will be conducted during the in-water work period to the extent practicable.													
Delta Smelt[1]													
Adults	All BDCP subregions but most abundant in West Delta and Cache Slough												
Larvae	All BDCP subregions but most abundant in West Delta, Cache Slough, Suisun Marsh, and Suisun Bay												
Sub-Adults	All BDCP subregions but primarily in Suisun Bay, West Delta and Cache Slough												
Longfin Smelt[2]													
Adults	All BDCP subregions but are most abundant in the West Delta, Suisun Marsh, and Suisun Bay												
Larvae	All BDCP subregions but are most abundant in the West Delta, Suisun Marsh, and Suisun Bay												
Sub-Adults	Primarily in West Delta, Suisun Marsh, and Suisun Bay												
Splittail[3]													
Adults/ spawners	All BDCP subregions migrating to floodplains and backwaters to spawn												
Larvae	In all BDCP subregions except Suisun Marsh and Suisun Bay with highest abundance in subregions with floodplains, Yolo and East Delta												
Juveniles	All BDCP subregions moving down river corridors to Suisun Marsh and Suisun Bay												
Green Sturgeon[4]													
Adults	Suisun Bay, West Delta, North Delta, Cache Slough, South Delta												
Larvae-post larvae ≤ 10 mo.													
Juveniles	All BDCP subregions												

Species	Distribution	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
White Sturgeon[5]													
Adult spawners	All BDCP subregions, except East Delta												
Adult estuarine feeders	All BDCP subregions												
Juveniles	All BDCP subregions												
Pacific Lamprey[6]													
Adults	All BDCP subregions to spawning areas												
Ammocoetes	All BDCP subregions except Suisun Bay and Suisun Marsh												
Macropthalmia	All BDCP subregions												
River Lamprey[7]													
Adults	All BDCP subregions to spawning areas												
Ammocoetes	All BDCP subregions												
Macropthalmia	All BDCP subregions												
Note: Shading indicates the period of expected presence. Darker shadings indicate potentially higher abundance. Hatched area indicates in-water work window period.													

Table 5.H.3-2. Potential Monthly Distribution of Adults and Juveniles of Salmonids

Species	Distribution	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Typical in-water construction window for *CM1 Water Facilities and Operation*. Note in-water construction activities for other conservation measures are currently unknown but will be conducted during the in-water work period to the extent practicable.													
Fall-Run Chinook Salmon[8]													
Adults	All BDCP subregions but most abundant in North and West Delta												
Juveniles	All BDCP subregions												
Late Fall–Run Chinook Salmon[9]													
Adults	North and West Delta												
Juveniles	North and West Delta and possibly all BDCP subregions												
Winter-Run Chinook Salmon[10]													
Adults	Sacramento River corridor of Yolo Bypass, Cache Slough, North Delta, and West Delta												
Juveniles	All BDCP subregions, but primarily within the Sacramento River corridor of Yolo Bypass, Cache Slough, North Delta, and West Delta												
Spring-Run Chinook Salmon[11]													
Adults	Primarily within the Sacramento River corridor of Yolo Bypass, Cache Slough, North Delta, and West Delta												
Juveniles	Primarily within the Sacramento River corridor of Yolo Bypass, Cache Slough, North Delta, and West Delta												
Steelhead, Central Valley Distinct Population Segment (DPS)[12]													
Adults	All BDCP subregions but most abundant in West and North Delta												
Juveniles	In all BDCP subregions but most abundant in the North Delta subarea												
Note: Shading for salmonids indicates potential abundance based on actual catch data described in Appendix 2.A, *Species Accounts*. Darker shades indicate potential higher abundance. Hatched area indicates in-water work window period.													

Sources for Table 5.H.3-1 and Table 5.H.3-2:

[1] Bennett 2005; Baxter et al. 2008; California Department of Fish and Game 2007; Moyle et al. 1992; Nobriga and Herbold 2009; Sommer et al. 2011.

[2] Rosenfield 2010; Hieb and Baxter 1993; Baxter 1999a; Dege and Brown 2004; Bennett et al. 2002; Moyle 2002; Hobbs et al. 2006; Rosenfield and Baxter 2007; Feyrer et al. 2003.

[3] Baerwald 2007; Moyle et al. 2004; Feyrer et al. 2005; Crain et al. 2004; T. Ford pers. comm.; T. Heyne pers. comm.; M. Horvarth pers. comm.; Baxter 1999b; Sommer et al. 1997; Caywood 1974; Meng and Matern 2001; Daniels and Moyle 1983; Sommer et al. 2001; Feyrer and Baxter 1998; Kratville 2008.

[4] U.S. Fish and Wildlife Service 2002a; Moyle et al. 1992; Adams et al. 2002; National Marine Fisheries Service 2005a; Kelly et al. 2007; California Department of Fish and Game 2002; BDAT, fall midwater trawl green sturgeon captures from 1969 to 2003; Nakamoto et al. 1995; Heublein et al. 2006.

[5] Moyle 2002; Surface Water Resources 2004; Welch et al. 2006; Pacific States Marine Fisheries Commission 1996; Kolhorst 1976; Wang 1986; Israel et al. 2009; Schaffter 1997.

[6] Morrow 1980; Moyle 2002; Brown and Moyle 1993; Streif 2008; Ruiz-Campos and Gonzalez-Guzman 1996; Renaud 2008; Swift et al. 1993; Roffe and Mate 1984.

[7] Moyle 2002; Vladykov and Follett 1958; Moyle et al. 1995; Beamish and Youson 1987; Beamish and Neville 1995; Streif 2008.

[8] State Water Project and Federal Water Project fish salvage unpublished data 1981–1988; Yoshiyama et al. 1998; Moyle 2002; Martin et al. 2001; Snider and Titus 2000; U.S. Fish and Wildlife Service 2001.

[9] State Water Project and Federal Water Project fish salvage unpublished data 1981–1988; Yoshiyama et al. 1998; Moyle 2002; Martin et al. 2001; U.S. Fish and Wildlife Service 2001; Jones & Stokes Associates, Inc. 2002; S. P. Cramer and Associates, Inc. 2000, 2001; Schaffter 1980.

[10] Yoshiyama et al. 1998; Moyle 2002; Myers et al. 1998; Martin et al. 2001; Snider and Titus 2000; U.S. Fish and Wildlife Service 2006; Jones & Stokes Associates, Inc. 2002; S.P. Cramer and Associates, Inc. 2000, 2001; Schaffter 1980.

[11] Yoshiyama et al. 1998; Moyle 2002; Myers et al. 1998; Lindley et al. 2006; California Department of Fish and Game 1998; McReynolds et al. 2005; Ward et al. 2002, 2003; Snider and Titus 2000; U.S. Fish and Wildlife Service 2001; Jones & Stokes Associates, Inc. 2002; S.P. Cramer and Associates, Inc. 2000, 2001; Schaffter 1980.

[12] Hallock et al. 1961; McEwan 2001; California Department of Fish and Game 1995; Hallock et al. 1957; Based on limited unpublished data from DFG Steelhead Report Card; California Department of Fish and Game unpublished data; Nobriga and Cadrett 2003.

5.H.4 Construction and Maintenance Activities

This section contains a brief overview of the conservation measures and associated construction and maintenance activities that potentially could affect covered fish species. Chapter 3 includes detailed descriptions of each of these conservation measures.

5.H.4.1 Construction Activities

5.H.4.1.1 CM1 Water Facilities and Operation

Construction activities associated with *CM1 Water Facilities and Operation* include: constructing three north Delta intakes, installing pipelines connecting the intakes to an intermediate forebay in the North Delta subregion, constructing tunnels along the eastern edge of the Delta (North Delta, West Delta, South Delta subregions), and constructing the Byron Tract Forebay in the South Delta subregion. Inverted siphon structures will be constructed to connect certain pipeline facilities. The following sections describe the construction and maintenance activities associated with *CM1 Water Facilities and Operation* that have the potential to affect covered fish species.

5.H.4.1.1.1 Construction of Intakes

Three intake facilities (Intakes 2, 3, and 5) between about Sacramento River Mile (RM) 41 (about 1 mile upstream of Clarksburg) and RM 37 (about 2 miles upstream of the town of Courtland) will be constructed, affecting the Sacramento River channel and bank. The location, dimensions, and construction footprints of each of the intakes are provided in Table 5.H.4-1. A single intake, along with the infrastructure needed to construct it (e.g., cofferdam), is shown in Figure 5.H.4-1.

1 **Table 5.H.4-1. Dimensions of North Delta Intakes and Associated Construction Footprints**

North Delta Intake No.	Intake Construction Duration	Pile Driving Duration[1,2]	Location (River Mile)	Length of Screened Intake (feet)[3]	Total Intake and Transition Wall Length (feet)[3]	In-Water Area Temporarily Isolated inside Cofferdam (acres)	In-Water Area Permanently Affected by Screened Intake Footprint (acres)	Dredging Area Outside of Cofferdams (acres)
2	December 2017 to August 2021	June to September 2019	41	1,800	2,400	3.1	2.1	4.5
3	September 2017 to July/August 2021	June to October 2019	40	970	1,560	1.6	1.1	2.7
5	October 2017 to July 2021	July to October 2019	37	1,650	2,400	2.8	1.9	4.9
Total				4,420	6,360	7.5	5.1	12.1

[1] It is anticipated that 16 feet of cofferdam could be built in a single day.
[2] It is anticipated the barge landing pile driving would occur during the same time period as the cofferdam pile driving.
[3] Estimates based on intake designs from GIS Revision 10.

2

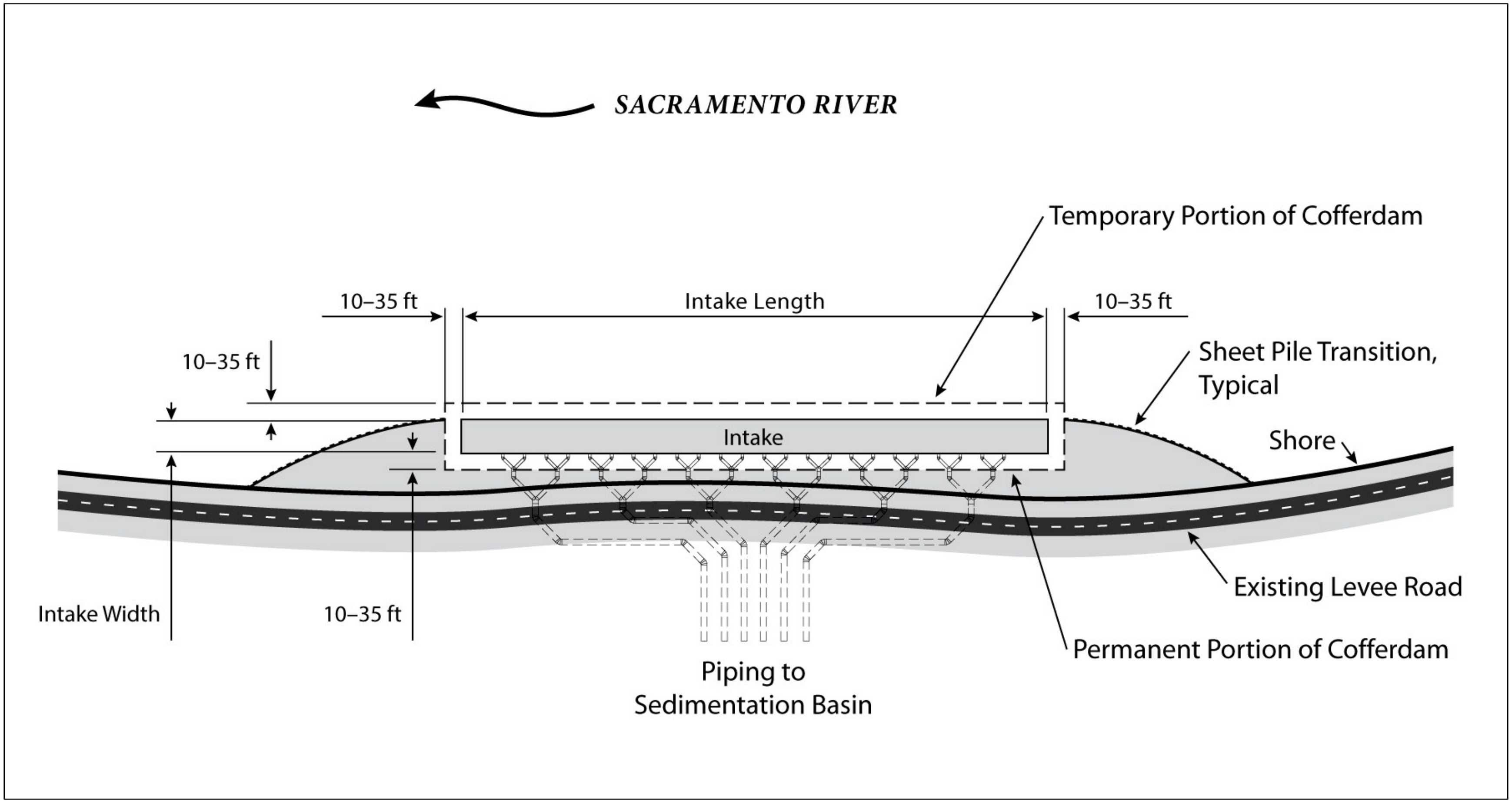

Figure 5.H.4-1. Representative Intake with Cofferdam and Transition Walls

Constructing the three intakes is expected to take between 3.5 and 4.5 years to complete, with all of the intakes constructed concurrently. Constructing each intake will involve installing a sheet-pile cofferdam in the river during the first construction season (June through October, 2017), which will isolate a majority of the in-water work area around each intake during the remaining years of the intake construction process. Some clearing and grubbing at the construction site may be required prior to installing the sheet-pile cofferdam, depending on site conditions (e.g., presence of vegetation and/or riprap bank protection). Clearing and grubbing activities may include removing riprap, vegetation, and garbage from the levee and/or channel area within the aquatic habitat, depending on the specific placement of the sheet piles and the existing conditions. Once the cofferdam is installed, the area within the cofferdam will be dewatered, to the extent possible. Water pumped from within the cofferdams will be treated (removing all sediment), using settling basins or Baker tanks, and returned to the river. Following dewatering, the area behind the newly constructed cofferdam is no longer considered "in-water." Work within the cofferdam will progress, with excavation and foundation-pile installations to support the intake structures but with no or substantially minimized effects on the aquatic environment.

Each of the three cofferdams (one at each intake) will be constructed during the first construction season (see Table 5.H.4-1). Although multiple pile drivers likely will be needed to construct each intake cofferdam because of their overall size, the primary use of vibratory pile driving methods to install the sheet-pile cofferdam sections will minimize effects of underwater noise on fish. Vibratory pile driving does not generate underwater sound levels to cause instantaneous or cumulative injury to fish. Pile driving generally will be restricted to a typical 8-hour, daylight-only work day during the approved in-water work window.

The geological conditions at each site are not yet known, and it is probable that some portion of the sheet piles will need to be impact-driven because of subsurface conditions. For a conservative estimate, it was assumed that the proportion of sheet piles needing to be impact-driven would be similar to that experienced at the nearby Freeport intake facility (30%). It is not possible to use standard sound attenuation devices for sheet pile because these devices need to completely encircle the impact-driven pile to be effective, while sheet piles are interlaced and thus cannot be effectively encircled.

Once the geotechnical work is complete, California Department of Water Resources (DWR) will be able to estimate more accurately the locations and amount of impact driving necessary to achieve the engineering requirements of the sheet-pile cofferdam (some of which likely will remain in place and become a permanent part of the intake structure). To the extent practicable, impact pile driving will not occur simultaneously at adjacent intakes, minimizing the potential for overlapping sound fields from adjacent intakes. This also will minimize the total area where cumulative sound levels exceed the threshold in a given day, and provide additional noise refuges for fish along the entire length of river where the intakes are constructed.

5.H.4.1.1.2 Intake Site Dredging

It is assumed that after the intakes are completed and the cofferdam removed, the area in front of the intake will need to be dredged to provide appropriate flow conditions at the intake entrance. Although initial estimates of these areas are provided in Table 5.H.4-1, these are only approximate and are based on preliminary geotechnical data. If required, the dredging will occur during the approved in-water work window and will be minimized to the maximum extent practicable. It is also assumed that periodic maintenance dredging may be needed to maintain appropriate flow conditions.

5.H.4.1.1.3 Construction of Pipelines and Portals

Covered activities will involve subsurface conveyance pipelines and portal structures to access subsurface tunnels. The subsurface tunnels will be constructed from portals that will provide access for equipment and materials, and for removing tunnel muck. These portals and tunnel muck storage areas all will be located in upland areas and will not affect the aquatic environment. These areas will be designed to minimize the potential for stormwater runoff to surface waters; therefore, they will not be discussed in this appendix.

5.H.4.1.1.4 Construction of Barge Landings

Six temporary barge landing sites will be constructed to provide access for equipment and materials barged to the portal construction sites. The six barge landings are located on or near the locations listed below.

- State Route (SR) 160 west of Walnut Grove
- Venice Island
- Bacon Island
- Woodward Island
- Victoria Island
- Tyler Island

The specific design of the barge landings is unknown at this time, but typically will include temporary docks supported by piles driven in the river, although floating barges will be used when possible to minimize in-water construction activities.

5.H.4.1.2 Conservation Measures Focused on Restoration

Restoration construction activities, under *CM2 Yolo Bypass Fisheries Enhancement, CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement, CM7 Riparian Natural Community Restoration, and CM10 Nontidal Marsh Restoration*, also may affect covered fish species. Restoration will likely include pre-breach management of the restoration site to promote desirable vegetation and elevations within the restoration area and levee maintenance, improvement, or redesign. This may require substantial earthwork outside, but adjacent to, tidal and other aquatic environments. Levee breaching will require removing levee materials from within and adjacent to tidal and other aquatic habitats. These materials could be placed on the remaining levee sections, placed within the restoration area, or hauled to a disposal area. Some restoration may include much more extensive construction activities, specifically restoration activities in the Yolo Bypass, where drainage and other agricultural facilities may need to be installed or relocated. Table 5.H.2-1 summarizes this information by conservation measure.

5.H.4.1.2.1 CM2 Yolo Bypass Fisheries Enhancement

The expected Fremont Weir and Yolo Bypass construction activities are listed below.

- Modifying the Fremont Weir and Yolo Bypass.
- Constructing a deep fish passage channel in the Yolo Bypass.
- Replacing the Fremont Weir fish ladder.
- Constructing experimental sturgeon ramps at the Fremont Weir.
- Modifying the stilling basin.
- Improving the Sacramento Weir.
- Making improvements at the Tule Canal/Toe Drain.
- Realigning lower Putah Creek.

5.H.4.1.2.2 CM4 Tidal Natural Communities Restoration

Tidal habitat restoration is expected to provide habitat for most of the covered fish species, although the use of specific restored areas will vary by species and life stage. *CM4 Tidal Natural Communities Restoration* will occur in the restoration opportunity areas (ROAs) of Suisun Marsh, Cache Slough, West Delta, South Delta, and the Cosumnes-Mokelumne Rivers. The restoration measures are expected to improve conditions gradually over time, as the restorations mature functionally. However, the biological goals (species responses) typically are expected to occur by year 15. Below is a list of construction activities for tidal habitat restoration.

- Excavating channels to encourage the development of sinuous, high-density, dendritic channel networks within restored marsh plain.
- Modifying ditches, cuts, and levees to encourage more natural tidal circulation and better flood conveyance based on local hydrology.
- Removing or relocating infrastructure, including levee breaching to restore tidal connectivity.
- Removing existing levees or embankments or creating new structures to allow restoration to take place while protecting adjacent land.
- Prior to breaching, recontouring the surface to maximize the extent of surface elevation suitable for establishment of tidal marsh vegetation (marsh plain) by scalping higher elevation land to provide fill for placement on subsided lands to raise surface elevations.
- Prior to breaching, importing dredged or fill material and placing it in shallowly subsided areas to raise ground surface elevations to a level suitable for establishment of tidal marsh vegetation (marsh plain).
- Prior to breaching, cultivating stands of tules through flood irrigation for sufficiently long periods to raise subsided ground surface to elevations suitable to support marsh plain. Levees will be breached when target elevations are achieved. Irrigation infrastructure and levees will need to be installed or retained to control irrigation during the establishment period.
- Possibly constructing dikes to maintain existing land uses when tidal habitat is restored adjacent to farmed lands or lands managed as freshwater seasonal wetlands.

5.H.4.1.2.3 CM5 Seasonally Inundated Floodplain Restoration

Construction activities to restore floodplains are listed below.

- Lowering the elevation of restored floodplain surfaces or modifying river channel morphology to increase inundation frequency and duration and to establish elevations suitable for the establishment of riparian vegetation by either active planting or allowing natural establishment.
- Setting levees back along selected river corridors and removing or breaching levees.
- Removing existing riprap or other bank protection to allow for channel migration between the setback levees through the natural processes of erosion and sedimentation.
- Modifying channel geometry in unconfined channel reaches or along channels where levees are set back in order to create backwater habitat.
- Selectively grading restored floodplain surfaces to provide drainage of overbank floodwaters such that the potential for fish stranding is minimized.
- Actively establishing riparian habitat on floodplains.

5.H.4.1.2.4 CM6 Channel Margin Enhancement

Channel margin enhancement actions often will be implemented in conjunction with seasonally inundated floodplain and riparian natural community restoration conservation measures (*CM5 Seasonally Inundated Floodplain Restoration* and *CM7 Riparian Natural Community Restoration*, respectively).

Below is a list of channel margin enhancements.

- Removal of riprap from channel margins where levees are set back to restore seasonally inundated floodplains.
- Modification of the outboard side of levees or setback levees to create low floodplain benches with variable surface elevations that create hydrodynamic complexity and support emergent vegetation.
- Installation of large woody material (e.g., tree trunks and stumps) into constructed low benches or into existing riprapped levees to provide physical complexity.
- Planting of riparian and emergent wetland vegetation on created benches.

5.H.4.1.2.5 CM7 Riparian Natural Community Restoration

Riparian natural community restoration will include the establishment/reestablishment of forest and scrub vegetation in restored floodplain areas (*CM5 Seasonally Inundated Floodplain Restoration*), consistent with floodplain land uses and flood management requirements. Riparian restoration also will be a component in some *CM4 Tidal Natural Communities Restoration* and *CM6 Channel Margin Enhancement* restoration projects.

5.H.4.1.3 Other Conservation Measures That Include Construction

Other conservation measures that include construction activities with the potential to affect covered fish are *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, *CM15* Localized Reduction of *Predatory Fishes*, *CM16 Nonphysical Fish Barriers*, *CM18 Conservation Hatcheries*, *CM19 Urban Stormwater Treatment*, and *CM21 Nonproject Diversions* (Table 5.H.0-1 and Table 5.H.2-1). All of these conservation measures will require at least some in-water work to install and/or remove facilities. Additionally, some work will be on the levee or bank adjacent to aquatic habitat.

CM16 Nonphysical Fish Barriers specifically involves installing piles to support the nonphysical barrier structure within the channel in addition to placing telemetry equipment up- and downstream of the barrier. Nonphysical barriers that may be installed probably will be similar to the three-component barriers tested at the head of Old River in 2009–2010 and at Georgiana Slough in 2011 (ICF International 2010; California Department of Water Resources 2012). The design consists of a multi-stimulus fish barrier that combines high intensity light–emitting diode (LED) modulated intense lights (MILs), an air bubble “curtain,” and sound at frequencies and levels that are repellent to Chinook salmon (Bowen et al. 2009; Bowen and Bark 2010). Nonphysical barriers will differ in length based on the width of channel that fish are to be deterred away from. For example, the Georgiana Slough barrier scheduled to be tested in 2011 was around 700 feet long with 18 piles (ICF International 2010) whereas the head of Old River barriers tested in 2009 and 2010 were around 370 and 450 feet long, respectively, and included four piles (Bowen et al. 2009; Bowen and Bark 2010). Typical piles are 12-inch-diameter, open-end steel pipes that are driven with a vibratory pile driver in the wetted channel from a barge. Concrete pier blocks also may be placed to provide additional support to the barrier frame structure; four such pier blocks covering 16 square feet each were required for the 2011 Georgiana Slough nonphysical barrier, for example (ICF International 2010; California Department of Water Resources 2012). Depending on the exact location, vegetation and/or riprap may need to be removed to ready the channel for the piles and the remainder of the structure (light, sound, and air supply).

CM21 Nonproject Diversions will involve removal of individual diversions that have relatively large effects on covered fish species; consolidation of multiple smaller unscreened diversions into a single or fewer screened diversions placed in lower quality habitat; or reconfiguration and screening of individual diversions in higher-value habitat. This will involve on-bank construction activities such as clearing vegetation and in-water work such as possible dredging and modifications of pipe and in-water structures and placing a screen over existing diversions. If consolidation of multiple smaller diversions occurs, a sheet-pile cofferdam will be needed on the water side of the riverbank along the outermost edge of the intake structure footprint. While cofferdam construction will vary based upon the soil that exists in each work area, it is likely that sheet piles will be installed using vibratory methods. Once completed, the cofferdam will be dewatered prior to the installation of the intake structure foundation, where feasible. The sheet piling will extend to the top of the sloped soil bank. A pile foundation for the intake structure then will be installed by driving piers within the dewatered in-channel section of the cofferdam and within the bank section of the cofferdam. If dewatering is not feasible, a bubble curtain (or similar device) will be used to minimize underwater sound levels from pile driving. These piers will extend beneath the structure and down into the substrate. A pipeline will be constructed from the intake structure to the pump station. The length and diameter will be based on site-specific and project-specific requirements, but construction impacts associated with the pipeline installment will be similar. The alignment for the pipeline will be excavated from the bank of the river using an extended-arm excavator.

5.H.4.2 Maintenance Activities

5.H.4.2.1 CM1 Water Facilities and Operation

The proposed intake facilities will require routine or periodic adjustment and tuning to remain consistent with design intentions. Facility maintenance will include activities such as painting, cleaning, repairs, and other routine tasks to operate facilities in accordance with design standards after construction and commissioning. Many of these maintenance activities will not be conducted in water or have the potential to affect covered fish. However, maintenance activities associated with river intakes could include removing sediment, debris, and biofouling materials. These maintenance activities could require suction dredging or mechanical excavation around intake structures; dewatering; or use of underwater diving crews, boom trucks or rubber wheel cranes, and raft- or barge-mounted equipment. Maintenance dredging will be conducted periodically, as necessary to return the bathymetry adjacent to the intakes to the as-built condition. This maintenance dredging typically will be limited to the approved in-water work window (June through October) to minimize potential effects on the covered species. Routine visual inspection of the facilities will be conducted to monitor performance and prevent mechanical and structural failures of project elements.

5.H.4.2.2 Conservation Measures Focused on Restoration

Maintenance of restoration areas may include dredging or other earthwork, vegetation removal or installation, and maintenance of drainage or other facilities constructed or included in the restored area. Most of the proposed restoration activities are designed to require as little maintenance as possible, but over the 50-year permit period, some maintenance may be required to ensure the best possible performance of these sites. Typically, maintenance for the restoration projects will consist of the following activities.

- Watering/irrigation (limited to transition and/or upland areas for tidal wetland projects).
- Weed removal/control.
- Re-planting.
- Debris removal.
- Sediment removal.
- Vegetation pruning/culling/removal.

Levee maintenance may be needed for some sites and could include activities such as grading, breach repair, and riprap replacement. Other restoration maintenance activities are listed below.

- Water control structure maintenance/replacement (canal gates, flashboard risers).
- Infrastructure maintenance/replacement (fences, gates, gravel access roads).
- Instream woody material replacement.

Periodically, maintenance activities in the Yolo Bypass subregion (*CM2 Yolo Bypass Fisheries Enhancement*) may include sediment removal from the Fremont Weir area using graders, bulldozers, excavators, dump trucks, or other machinery. A recent record of maintenance activities indicates that it will be reasonable to expect approximately 1 million cubic yards (MCY) of sediment may be removed within 1 mile of the weir an average of every 5 years. An additional 1 MCY of sediment conservatively is anticipated to be removed inside the new channel every other year as part of routine sediment management activities. Where feasible, work will be conducted under dry conditions; some dredging may be required to maintain connection along the deepest part of the channel for fish passage.

5.H.4.2.3 Other Conservation Measures

Of the remaining conservation measures (*CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, *CM15 Localized Reduction of Predatory Fishes*, *CM16 Nonphysical Fish Barriers*, *CM18 Conservation Hatcheries*, *CM19 Urban Stormwater Treatment*, and *CM21 Nonproject Diversions*), all but *CM15 Localized Reduction of Predatory Fishes* may require maintenance, but any maintenance will be expected to be very minimal. Maintenance activities may include clearing debris from around the nonphysical barrier, aeration facilities, or bioretention facilities, and making repairs to the facilities. Major repair or maintenance likely will be conducted outside of the aquatic environment.

5.H.5 Methods Used to Evaluate Potential Construction and Maintenance Effects on Covered Fish Species

The methods used to evaluate the potential effects of construction and maintenance activities on covered fish species are discussed below according to specific stressors of concern, including potential increases in underwater sound above fish tolerance levels, degradation of water quality, habitat modification, and physical injury and loss of individual fish.

5.H.5.1.1 Underwater Sound

Pile driving will be the primary source of underwater sound. Two types of pile driving will occur: impact pile driving (generating potentially adverse underwater sound levels) and vibratory pile driving (generating sound levels not considered adverse to fish). The construction of *CM1 Water Facilities and Operation* likely will use both impact and vibratory pile driving, and CM16 will use only vibratory pile driving. *CM1 Water Facilities and Operation* will consist of driving sheet piles and support piles to construct the cofferdams, as well as the intake foundation piles installed inside of the completed and dewatered cofferdams. However, if dewatering is not feasible, a bubble curtain or similar device will be used to minimize in-water impact–pile driving sound levels. While these intake foundation piles may be cast-in-drilled-hole (CIDH) construction, requiring little or no pile driving (only for limited testing to ensure that they have adequate bearing capacity), this analysis assumes the worst-case scenario of driving the foundation piles with a combination of vibratory and impact hammer methods. Constructing the restoration or other conservation measures will not use pile driving and therefore will not generate underwater sound at levels of concern.

Underwater sound generated by pile driving in or near surface waters potentially can harm covered fish. Because of geologic or other conditions at some sites, some piles likely will require impact pile driving for installation[1]. Research indicates that impact pile driving can result in injuries to fish if

[1] It should be noted that DWR proposes to use a vibratory driver/extractor for constructing the cofferdam, landing piles, and removing existing and temporary piles or use CIDH methods for the foundation piles. Vibratory and CIDH pile installation methods have low potential for adverse effects on fish. However, geological conditions have not

the peak sound pressure levels are high enough or exposure is long enough. DWR intends to use vibratory (or other nonimpact) methods to install cofferdam, intake foundation, and barge landing piles, to the maximum extent practicable. Vibratory pile driving is assumed not to produce sound pressure levels that could injure fish or substantially alter their behavior. In-water pile driving typically will occur only during the approved in-water work windows to minimize the potential for covered fish species to be exposed to harmful underwater sound pressure levels. Pile driving outside of the approved work window typically will occur inside dewatered cofferdams, or within a bubble curtain (or similar device) to minimize sound levels and potential fish injuries.

Pile driving with the potential to cause underwater noise at levels of concern includes all impact pile driving activities, including of sheet piles for the cofferdams at the intake sites, foundation piles for the intake structures, piles to support temporary docks at the barge landing sites, and piles installed for the nonphysical barriers. However, vibratory pile driving will be used at all these locations, to the maximum extent practicable, to minimize potential effects.

Underwater sound associated with *CM1 Water Facilities and Operation* impact pile driving is evaluated quantitatively. Underwater sound associated with vibratory pile driving is considered to have substantially fewer effects on fish and therefore is not analyzed quantitatively.[2]

Details on construction of cofferdams, foundation piles, and barge landings are not known at this time, so a number of very conservative assumptions and published information[3] and information from other in-water construction projects (e.g., Freeport intake construction and Red Bluff Diversion Dam construction) were used to evaluate the potential effects on fish resulting from underwater sound during construction. The specific approach is included below.

- Developing assumptions associated with pile driving.
- Determining underwater sound levels generated from impact pile driving developed by the California Department of Transportation (Caltrans) (2009) and estimating the attenuation of sound using a spreadsheet model created by the National Marine Fisheries Service (NMFS) (2009).
- Applying pile-driving assumptions to the presence and life stages of covered fish species to determine whether effects will occur.

Approximately 30% of the cofferdam sheet piles installed to construct the Freeport intake required impact driving. Therefore, as a conservative assumption, it was assumed for this analysis that 30% of the cofferdam, foundation, and barge landing piles will require impact driving under *CM1 Water Facilities and Operation*, despite indications from preliminary geotechnical surveys that suggest a greater level of vibratory pile driving may be achievable at the intake sites.

Effects threshold criteria are based on criteria specified in Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities (Fisheries Hydroacoustic Working Group 2008). Four sound metrics are commonly used in evaluating underwater noise (hydroacoustic)

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been evaluated at specific sites, and based on other projects in the area (e.g., Freeport), some impact driving likely will be necessary.

[2] NMFS assumes that there may be a behavioral response (startle response or avoidance) for fish exposed to sound levels above 150 dB RMS. It is generally assumed that vibratory pile driving may cause fish might to avoid the area when it is occurring, but it does not result in any injury or mortality.

[3] Underwater sound monitored and reported by California Department of Transportation (2009).

impacts on fish. Refer to Caltrans guidance (2009) for a detailed discussion of sound metrics and analysis methods[4].

- Peak sound pressure level (PEAK) is the highest sound pressure level experienced during a single pile strike.
- Single-strike sound exposure level (SEL) is a measure of the total sound energy associated with a single-strike event normalized to one second.
- Cumulative SEL ($SEL_{cumulative}$) is a measure of the cumulative sound energy that occurs over the duration of a day of impact pile driving exposure. $SEL_{cumulative}$ is calculated from the single-strike SEL and the number of strikes per day.
- RMS (root mean squared) sound pressure level is the square root of the mean squared pressure (the average of the squared pressures over the period of time that contains the portion of the waveform that includes 90% of the sound).

Dual interim criteria were developed by the Fish Hydroacoustic Work Group to identify the maximum underwater sound levels that are not expected to injure fish. The dual thresholds for impact pile driving are 206 decibels (dB) for the peak sound pressure level, and 187 dB for the $SEL_{cumulative}$ for fish larger than 2 grams, and 183 dB $SEL_{cumulative}$ for fish smaller than 2 grams. The $SEL_{cumulative}$ threshold is based on the cumulative daily exposure of a fish to noise sources that are discontinuous (e.g., only occur for 1–12 hours in a day, with more than 12 hours between exposure). Although not well-documented, NFMS assumes that there may be a behavioral response (startle response or avoidance) for fish exposed to sound levels above 150 dB RMS.

The methods used to evaluate potential underwater sound effects on covered fish from construction activities are very conservative in that a “reasonable worst case” approach is taken to estimate the duration and area affected by impact pile driving. DWR proposes to use a vibratory pile driver to install all driven piles. However past experience at nearby locations in the Sacramento River indicates that this may not be feasible. As such, the analysis includes a conservative assumption that a relatively large proportion (30%) of the pile driving will require impact driving and uses the maximum number of strikes likely to occur in a day to estimate $SEL_{cumulative}$. In addition, some or all of the foundation piles could be CIDH construction, which will eliminate or substantially minimize any pile driving within the cofferdams.

The interim criteria also are set to be conservatively protective of fish. Recent research (California Department of Transportation 2010; Ruggerone et al. 2008) has demonstrated that barotrauma (physical injury to organs and tissues from sound pressure waves) or mortality did not occur in fish exposed to $SEL_{cumulative}$ exposures in the range of 194 to 207 dB $SEL_{cumulative}$, well above the interim criteria. To date, however, NMFS has not indicated that they will accept a higher threshold. Further, the NMFS model assumes that a fish is stationary within the impact area throughout the entire exposure (a day of pile driving). However, most of the covered species are expected to use the river reach near the intakes primarily as a migratory corridor, and studies indicate relatively fast migration rates for a number of the covered species (Del Real et al. 2011; Holbrook et al. 2009; Heublein et al. 2008; Parsley et al. 2008; Vogel 2010).

[4] In this document, all underwater peak and RMS decibel levels are referenced to 1 micropascal (μPa), and SEL values are referenced to 1 μPa2-second.

The assumed sound attenuation rate used in the model is also conservative. The distance to attenuation assumes open water, and therefore overestimates the criteria for narrow, sinuous (winding) water bodies like rivers and sloughs (sound radiates straight outward from the source and is attenuated as it encounters bends in the river/slough). Consequently, evaluating potential underwater sound effects on covered fish from the covered activities involved the following procedures.

- Estimating conservative source sound levels (peak and single-strike SEL at 10 meters from the driven pile) by comparing measured underwater sound levels collected during pile driving events where similar pile type, pile driver, and attenuation methods were used (California Department of Transportation 2009).
- Assuming that impact pile driving inside of a dewatered cofferdam will produce in-water sound levels at least 10 dB lower than a similar pile driven in the water, a similar attenuation level is expected with a bubble curtain during in-water pile driving of an individual pile.
- Estimating the number of impact pile strike per day. For this analysis, a maximum of 12 piles driven per day at each intake and 700 strikes per pile are used as conservative estimates.
- Using the NMFS developed spreadsheet model to estimate the $SEL_{cumulative}$ and the distance within which pile driving sound levels will exceed the peak and $SEL_{cumulative}$ interim criteria. Sound attenuates [decreases] underwater as the distance from the source increases[5].
- Identifying the distance for underwater sound to attenuate to below the interim criteria, and determining where any exceedances occur and potentially overlap with species presence to determine which species and life stages could be affected.
- Estimating the exposure of covered species, assuming that impact driving will occur 30% of the days falling within the in-water work window when the cofferdams are being constructed. For each barge landing, it should be assumed that 32 piles will be installed over a period of 15 workdays, and impact driving will occur on 5 of those days (30%).
- Assuming that in-water pile driving at each intake will take place only during the first year of construction, and during the approved in-water construction period.
- Assuming that pile driving inside the dewatered cofferdams (or within a bubble curtain or similar device) will occur at any time of the year.

Other sources of in-water noise include generator and engine vibration transmitted through the hulls of work barges and associated vessels, and dredge equipment. Noise levels produced by these sources typically are less than those associated with vibratory pile driving and are likely to be comparable to ambient noise conditions in the vicinity. For example, noise levels associated with barge and vessel operations are expected to be comparable to baseline noise produced by routine vessel traffic, which typically ranges from 160 to 190 dB_{peak} at a range of 10 meters, depending on vessel size (Marine Aggregate Levy Sustainability Fund 2009). Dredge equipment noise will vary depending on equipment type. As an example, cutterhead dredges produce noise levels from 165 to 185 dB_{peak} at 1 meter from the source (Clarke et al. 2002; Sakhalin Energy 2004), which equates approximately to 150 to 170 dB_{peak} at the standard reference distance of 10 meters used for hydroacoustic monitoring. Other types of construction equipment will be used within the dewatered work area around each intake site. Noise transmission from these sources will be effectively

[5] The NMFS spreadsheet uses an assumed transmission loss in the model.

contained by the work area to the extent that any noise transmitted to the aquatic environment is unlikely to exceed ambient conditions.

5.H.5.1.2 Water Quality

Construction and maintenance effects on water quality could result from in-water work and from stormwater discharges from upland construction areas adjacent to water bodies in the Plan Area. Potential effects are outlined below.

5.H.5.1.2.1 Erosion and Sedimentation

Once in the aquatic environment, eroded sediments can result in direct impacts on resident fishes through gill damage and reduced capacity to take in oxygen. Indirect impacts can include increased metabolic costs associated with reduced dissolved oxygen (DO) intake ability, and reduced foraging ability as the result of decreased visibility. These activities could adversely affect covered fish species and their habitat (U.S. Bureau of Reclamation et al. 2011).

5.H.5.1.2.2 Turbidity

Turbidity is a measure of water transparency that reflects the amount of suspended material within the water column. Turbidity in the Delta is often 20–40 nephelometric turbidity units (NTUs) and decreases to less than 10 NTUs during low-flow conditions. Turbidity increases in the rivers during high flows (to 250–500 NTUs) and is generally high in Suisun Bay (measurements of 50–100 NTUs are common) from tidal resuspension. Turbidity levels can be approximated from the inverse of Secchi depth measurements taken during stream surveys. For example, a Secchi depth of 25 centimeters (cm) indicates a turbidity of 30 NTUs, and a Secchi depth of 50 cm refers to a turbidity of 15 NTUs.

Although turbidity is an important characteristic for many native fish both to see prey and to hide from predators, fish responses to high turbidity may include avoidance /displacement, reduced foraging success, and increased predation risk (Meehan and Bjornn 1991; Bash et al. 2001). However, sensitivity to changes in turbidity varies by species and/or life stage, and reflects a balance between effective foraging ability and predator avoidance. As a result, turbidity-tolerant species (e.g., delta smelt) are more apt to benefit from increased turbidity, while turbidity-sensitive species (e.g., salmonids) are more prone to be negatively affected. Therefore, turbidity criteria for construction-related effects typically are based on increases over background levels, a basis applicable for a range of baseline conditions and species likely to encounter construction-generated turbidity (Section 5.H.6.1.3.1).

5.H.5.1.2.3 Toxins

Toxic substances are present in both water and sediment in the Delta aquatic environment. In-water construction activities will result in resuspension of sediments that may contain toxic contaminants. When the toxins are in river channel sediments, they can enter the food chain via benthic organisms. If contaminated sediments are disturbed and become suspended in the water column, they also become available to pelagic organisms, including covered species and planktonic food sources of covered species. Thus, construction-related disturbance of contaminated bottom sediments opens a potential pathway to the food chain and may increase the bioavailability of certain toxins. Because the toxins are entering the water column attached to sediment, their movement is closely linked to turbidity, which measures the amounts of particulates in the water column.

The potential effects of toxins on covered fish species will depend on the types and concentrations of the toxins in disturbed sediments. Unfortunately, there are few available chemical data for sediments in the Delta. Toxins that tend to bind to particulates do not mix homogeneously into the sediment, and concentrations can vary widely over a small area.

Of the urban-related toxic constituents identified in Appendix 5.D, *Contaminants*, metals (lead and copper), hydrocarbons, organochlorine pesticides, and polychlorinated biphenyls (PCBs) are common urban contaminants with the greatest affinity for sediments. Agriculture-related toxins include copper and organochlorine pesticides.

Lead, PCBs, and hydrocarbons (typically oil and grease) are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Lead, PCBs, and oil and grease all tend to adhere to soils, although some lighter components of oil and grease can become dissolved in water. Because they adhere to particulates, they tend to settle out close to the source and likely will be found at highest concentrations adjacent to the urban areas. PCBs are very persistent, adsorb to soil and organics, and bioaccumulate in the food chain. Lead also will adhere to particulates and organics but does not bioaccumulate at the same rate as PCBs. Hydrocarbons will biodegrade over time in an aqueous environment and do not tend to bioaccumulate; thus, they are not persistent.

Dredging has the potential for release of sediment contaminants during dredging of the channel and from beneficial uses and/or disposal of dredged material. Although these constituents are already present in the Delta waterways, they are present in the water within the sediments (i.e., pore water) and they are not readily available in the water column above the sediments. Dredging activities will result in some resuspension of the sediments. Measured sediment plumes from hydraulic dredging operations (Hayes et al. 2000) suggest that less than 0.1% of disturbed sediments and associated contaminants would likely be resuspended as a result of hydraulic dredging cutterhead operations. Therefore, the potential release of contaminants from suspended sediment is expected to be limited because many of the chemical constituents are lipophilic and will preferentially sorb or attach to organically enriched or fine particles of sediment. In addition, these sediments are expected to resettle to the bottom relatively quickly.

Upland disposal of dredge spoils for controlled decanting and potential beneficial uses could alter surface water quality conditions in adjacent receiving bodies. These spoils may contain a number of constituents at levels considered potentially toxic to organisms. At the spoils pond, most of the solids will settle out of the water, although a small portion may remain in suspension. Elutriate sampling will be used to monitor and control, if necessary, this potential impact on water quality (i.e., toxicity). All decant water will be held until it has been determined through analysis that the water will meet all water quality objectives and will not pose a threat to aquatic biota.

Intake construction and maintenance dredging volumes for *CM1 Water Facilities and Operation* have not been formally specified. However, the current estimates indicate the total dredging and channel reshaping surface area for *CM1 Water Facilities and Operation* is about 14.6 acres, including 12.1 acres of dredging outside of the cofferdams at the north Delta intakes. Annual maintenance dredging volumes are expected to be of a similar order of magnitude. These dredge areas are on the low end of the range for other dredging projects that have occurred in the lower river and estuary over the past decade. As substantial adverse contaminant exposures have not been reported from such projects, it is reasonable to conclude that the BDCP will not result in adverse effects from contaminant exposure. Moreover, the monitoring and adaptive management measures in

CM1 Water Facilities and Operation are expected to limit turbidity generation, further limiting the release of sediment-bound contaminants into the water column.

On this basis, construction and maintenance dredging and dredged materials management under the BDCP are not expected to result in significant contaminant-related effects on water quality, sediment quality, or covered fish species.

5.H.5.1.2.4 Methylmercury Production

Mercury is a toxin of concern in the Delta and is present throughout the Delta system as a result of historical mining operations. Inorganic mercury tends to stay sequestered in sediments but, under certain biogeochemical conditions, can be transformed to a more toxic and bioavailable form called methylmercury. Mercury methylation is primarily a product of sulfur-reducing bacteria and is supported in anoxic environments, such as marshes. The bacterial action, and thus the rate of methylmercury production, is dependent on a wide range of environmental parameters, including temperature, salinity, pH, oxygenation, and redox. Current understanding of the fate and transport of mercury and methylmercury in the Delta and potential effects on covered fish species is described in Appendix 5.D, *Contaminants*.

Production of methylmercury is not expected to result from construction and maintenance activities. As explained above, mercury methylation is achieved mainly by bacterial activity in anoxic environments. Construction activities will disturb and possibly suspend sediments that contain mercury into the water column, but this will not result in the bacterial activity that will result in methylation. In addition, *CM12 Methylmercury Management* provides procedures to minimize methylmercury production in restoration areas. This conservation measure also includes a framework to evaluate site-specific probability of elevated mercury concentrations, preconstruction site characterization of mercury levels, and monitoring and reporting requirements. For construction and operation of nonrestoration conservation measures where the probability of mercury methylation is low, permits may require preconstruction sediment characterization and appropriate best management practices (BMPs) to minimize suspension of mercury-contaminated sediments into the water column.

5.H.5.1.2.5 Accidental Spills

Construction-related activities may affect water quality through accidental spills of contaminants, including cement, oil, fuel, hydraulic fluids, paint, and other construction-related materials. Depending on the type and magnitude of an accidental spill, contaminants can directly affect growth and survival of covered fish species.

The first step in evaluating potential water quality effects was to screen construction and maintenance activities to identify those that have the potential to result in adverse effects on water quality and then define those effects. A summary of this screening methodology is presented in Table 5.H.5-1, and results are presented in Section 5.H.6. This screening was followed by assessments of appropriate avoidance and minimization measures, as described in *CM22 Avoidance and Minimization Measures* such as *AMM3 Stormwater Pollution Prevention* Plan, *AMM4 Erosion and Sediment Control Plan*, *AMM7 Barge Operations Plan*, and *AMM2 Construction Best Management Practices and Monitoring* to minimize potential water quality effects to the maximum extent practicable. Applicable state and federal permits will also require that water quality parameters such as turbidity remain below specified thresholds that are protective of covered fish species. The evaluation of effects on covered fish species was based on the potential for water quality effects to occur in the same area and timeframe as covered fish.

Table 5.H.5-1. Potential for Construction Activities to Affect Water Quality

Activity	Conservation Measures	Location	Potential Water Quality Effects	Avoidance and Minimization Measures
Channel dredging/excavation	4, 5, 15, 21	In-water	• Increased turbidity • Resuspension of toxins attached to sediments • Disturbance/removal of channel sediments • Injury or loss of benthic invertebrates	• AMMs establish BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels
Installation of sheet pile for cofferdam	1, 21	In-water	• Increased suspension of bottom sediments and turbidity • Suspension of toxic-contaminated sediment	• AMMs establish BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels
Pile driving	1, 16, 21	In-water	• Increased suspension of bottom sediments and turbidity • Suspension of toxic-contaminated sediment	• AMMs establish BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels
Discharge of treated water from dewatering activities	1	In-water	• None	• Water will be treated prior to discharge and will meet environmental commitments (see Appendix 3.C) • NPDES permit requirements
Stormwater discharge (from upland construction areas)	1, 2, 4, 5, 6, 7, 14, 15, 16, 18, 19, 21	In-water	• Small discharges from upland construction areas	• Subject to AMMs • NPDES Permit requirements
Accidental spills (from construction equipment)	1, 2, 4, 5, 6, 7, 14, 18, 19, 21	In-water	• Small discharges of petroleum products	• AMMs • Pollution prevention programs
Excavation for restoration	2, 4, 5, 6, and 7	In-water	• Increased suspended sediment • Mobilization of toxic-contaminated sediment	• AMMs establish BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels
Basin Plan = Central Valley Regional Water Quality Control Board's *Water Quality Control Plan for the Sacramento and San Joaquin River Basins*. BMPs = best management practices. NPDES = National Pollutant Discharge Elimination Service.				

5.H.5.1.3 Modification to Habitat

5.H.5.1.3.1 Removal/Destruction of Cover

Cover describes the physical components of an aquatic environment that provide shelter and hiding, resting, rearing, holding, and feeding areas for fish. Aquatic plants, trees, and large woody debris (e.g., tree limbs, logs, rootwads) provide cover. The occurrence of many aquatic species depends on the size, density, and continuity of suitable cover. Cover could be temporarily or permanently removed during restoration activities such as levee reconstruction and/or breaching.

5.H.5.1.3.2 Changes to Channel Hydraulics

Channel morphology, along with flow, affects hydraulics, and together channel morphology and hydraulics influence the conditions that support fish movements and provide holding, rearing, and spawning habitat. Depending on the size and location of levee breaches for habitat restoration, there could be temporary hydraulic changes until newly opened areas become stabilized. Stabilization occurs as sediment gradually fills in the sites, raising elevations and decreasing the tidal prism and associated flow velocities.

5.H.5.1.3.3 Changes in Salinity

Breaching of levees also could change the concentration and location of salinity gradients in the Delta by increasing tidal flows in wetland channels. The magnitude of the salinity effects will depend on the location and breach connection and the area of the new tidal wetlands.

5.H.5.1.3.4 Changes in Flow Velocities

Changes in tidal flow velocities are a concern when they are above the sustained swimming speeds of fish species. Chinook salmon are strong swimmers compared to delta smelt and can move in and out of high velocity areas if necessary. However, young splittail could be excluded from edge habitat if velocities are high. Velocity changes are less likely to affect steelhead, green sturgeon, and adult splittail. Excess velocities typically are addressed adaptively through modifications of breach locations and sizes (U.S. Bureau of Reclamation et al. 2011).

Spawning, rearing, and migration habitat of covered fish species (Section 5.H.3) could be temporarily or permanently disturbed or removed because of construction or maintenance activities. The methods for determining the temporary or permanent effects on habitat are discussed below.

For *CM1 Water Facilities and Operation*, existing habitat conditions of importance to fish were summarized using the Sacramento River Bank Protection Project revetment database (U.S. Army Corps of Engineers 2007). This database covers levees that are part of the Sacramento River Flood Control Project. In the Plan Area, the Sacramento River is one of the major channels important to covered fish species that is included in the database. The revetment database was used to summarize several features of existing habitat that may be important to covered fish species, including water depth, presence of revetment, emergent vegetation coverage, overhead cover, and woody material. The summary of bankline features was used to provide context for the potential effects of *CM1 Water Facilities and Operation* intake facilities. Each intake is expected to have between 0.6 and 1.2 miles of permanent shoreline habitat disturbance and 0.2 to 0.6 mile of temporary habitat disturbance (see Table 5.H.6-5 and Table 5.H.6-6).

For the remaining conservation measures, the exact location and timing of the construction are unknown. Therefore, a qualitative analysis regarding habitat modification was prepared using best professional judgment and the information in Section 5.H.3 on spawning, rearing, and migration habitats of covered fish species and the monthly presence of species by life stage in the Plan Area.

5.H.5.1.3.5 Changes in Turbidity and Nutrient Cycling

As described in Appendix 5.E, *Habitat Restoration*, overall turbidity is not expected to change as a result of habitat restoration. Habitat restoration could affect nutrient cycling and delivery of phytoplankton, zooplankton and nutrients in the Delta, with beneficial effects on covered species. For more details, please refer to Appendix 5.E, *Habitat Restoration*.

5.H.5.1.4 Physical Injury or Loss of Individuals

5.H.5.1.4.1 Entrapment

Physical injury or loss of individual fish could occur without proper precautions, although some injuries and losses may be unavoidable. For example, under *CM1 Water Facilities and Operation*, in-water work associated with facility construction may include the use of temporary barriers to buffer pile driving sounds. Use of these temporary barriers has the potential to entrap fish and result in physical injury or loss of individual fish during entrapment or fish removal.

5.H.5.1.4.2 Dredging/Excavation

Excavation along banks and channel dredging for CM1, CM2, CM4, CM5, CM6, CM7, CM14, CM15, CM16, CM18, CM19, and CM21 could cause excessive erosion or disturbance of bottom sediments. Suction dredging, mechanical excavation, and front end–loading equipment can capture or crush fish causing injury or mortality.

5.H.6 Results of Analysis of Construction Effects on Covered Fish Species

The following subsections discuss results of the analysis of potential stressors and effects resulting from construction activities. Results are organized according to conservation measure.

5.H.6.1 CM1 Water Facilities and Operation

5.H.6.1.1 Presence of Fish Species during Conservation Measure 1 Construction

5.H.6.1.1.1 Salmonids

In-water construction activities for *CM1 Water Facilities and Operation* will be scheduled in order to avoid the peak migrations of salmonids but will overlap with some early migrating (late fall-run), or late (spring-run) adults, early steelhead adults, or late emigrating juveniles. Juvenile salmon and occasional adult salmon also may be present near the barge landings during in-water construction of those sites.

5.H.6.1.1.2 Delta Smelt

While delta smelt typically occur well downstream, they occasionally occur in the intake construction areas around the spawning season. Although egg, larva, and adult life stages of delta smelt are all potentially present in the vicinity of the intake and barge landing areas during June, the timing of cofferdam installation (June through October) will avoid most of the spawning season when delta smelt are most likely to be present. The number of fish potentially migrating past the site of the intakes during the in-water construction window likely will be a very small portion of the overall population, based on run timing. Therefore, effects from construction at the intake sites on delta smelt are expected either not to occur or to be very minimal.

5.H.6.1.1.3 Longfin Smelt

Longfin smelt likely are not present in the Sacramento River near the intake facilities. Therefore, effects from construction at the intake sites on longfin smelt are expected either not to occur or to be very minimal.

5.H.6.1.1.4 Splittail

Although larva and juvenile stages of Sacramento splittail are potentially present in the vicinity of the intake and barge landing areas between April and July, their prevalence is likely very low. Typically, splittail are least prevalent in the north Delta, east Delta, and south Delta, and therefore the number of fish potentially present in the vicinity of the intakes and barge landings during the in-water construction window (June through October) will be limited. Although Sacramento splittail likely would be more abundant during wet years, the construction effects are expected to have minimal effects on their overall populations. Splittail are not expected to occur near the intake sites for extended periods because of the limited availability of preferred habitat (i.e., moderately shallow [less than 4 meters] brackish and freshwater tidal sloughs and shoals [Moyle et al. 2004; Feyrer et al. 2005]). These preferred habitats would be particularly less likely to occur at the intake areas during wet years because of the increased water depths and velocities in the confined channels adjacent to the intakes sites. In addition, the use of cofferdams will minimize potential construction effects in subsequent years, once they are installed.

5.H.6.1.1.5 Green and White Sturgeon

Adult and juvenile sturgeon could occur year-round in the Sacramento River but are expected to occur somewhat infrequently at the intake sites, as individuals from both species spend the majority of their overall lives in deep brackish portions of the estuary, or in the ocean (Moyle 2002; Surface Water Resources, Inc. 2004; Welch et al. 2006). A small number of adults could use the intake sites during the in-water construction window as a migratory corridor back to the ocean, and during the tail end of the spawning migration season in June, resulting in only a small portion of the population potentially affected. Therefore, the number of fish potentially migrating past the site of the intakes and barge landings during the in-water construction window will be relatively small compared to their overall spawning populations. However, juveniles are likely to be moderately affected during the first year of construction, when the cofferdams are installed. Entrainment during construction and maintenance dredging activities are also likely to result in injury or mortality to some juvenile and adult sturgeon.

5.H.6.1.1.6 Pacific and River Lamprey

Pacific and river lamprey ammocoetes are present year-round in the Sacramento River and possibly in the construction area. Presence of ammocoetes in the area is dependent on the substrate. Appropriate substrate is needed for burial of ammocoetes. Pacific lamprey adults migrate upstream to spawn between January and June, with spawning extending through August, while river lamprey primarily migrate between September and November and spawn through June (Beamish 1980; Moyle 2002; Streif 2007; Luzier et al. 2009). The ammocoetes will be rearing and adults will be using the area as a migratory corridor. The number of lamprey potentially migrating past the site of the intakes and barge landings during the in-water construction window will be small compared to their overall populations. However, individual ammocoetes present in the vicinity of in-water work activities are expected to be affected by these activities. Entrainment during construction and maintenance dredging are particularly likely to result in injury or mortality.

5.H.6.1.2 Underwater Sound

The following discussion summarizes the evaluation of underwater noise generated by pile driving activities with regard to potential adverse effects on fish. Predicted underwater sound levels are compared to the interim threshold criteria currently used by NMFS to assess potential injury to fish from pile driving. These injury threshold criteria are:

- 206 dB_{peak}
- 187 dB $SEL_{cumulative}$ for fish 2 grams or greater
- 183 dB $SEL_{cumulative}$ for fish less than 2 grams

These criteria relate to impact pile driving only. Vibratory pile driving is generally accepted as a mitigation measure for reducing detrimental underwater noise from pile driving and is not considered to result in injury to fish. This evaluation is based on conservative assumptions regarding the *CM1 Water Facilities and Operation* construction activities described in Section 5.H.4.1. Underwater sound levels were predicted using a spreadsheet model developed by NMFS. The calculation assumes that once the single-strike SEL value is attenuated to 150 dB there is no accumulation of sound energy relative to the cumulative SEL effects threshold. The distance at which the SEL value attenuates to 150 dB is therefore the maximum distance at which either of the cumulative SEL criteria can be exceeded.

5.H.6.1.2.1 Cofferdam Installations

Temporary cofferdams constructed with sheet piles will be required at each intake and culvert siphon site. These piles will be installed primarily with vibratory driving, although some impact driving likely will be necessary. Project engineers indicate that 8 to 12 sheet piles could be driven per day with up to 700 strikes per pile (8,400 strikes per day). Impact driving of sheet piles is anticipated to result in single-strike sound levels of 205 dB_{peak} and 180 dB SEL measured at a distance of 10 meters (California Department of Transportation 2009). Assuming attenuation at a rate of 4.5 dB per doubling of distance, the distances within which the criteria are predicted to be exceeded have been calculated and are provided in Table 5.H.6-1. The distance at which sound will attenuate to below 150 dB SEL is about 1,000 meters (3,280 feet), making this the maximum distance within which either the 183 dB or 187 dB $SEL_{cumulative}$ effects threshold criteria might be exceeded.

Table 5.H.6-1. Summary of Underwater Sound Levels Expected during Impact Pile Driving Activities and Distances Where Effect Thresholds May Be Exceeded

Pile Type	Number of Piles Driven per Day	Number of Strikes per Pile	Total Number of Strikes per Day	Peak Sound Level at 10 meters (dB_{peak})	Single Strike SEL at 10 meters (dB SEL)	Distance to 206 dB_{Peak} (meters)	Distance to 187 dB-$SEL_{cumulative}$ (meters)	Distance to 183 dB-$SEL_{cumulative}$ (meters)
Sheet pile	12	700	8,400	205	180	<10	1,000	1,000
24-inch-diameter steel pipe	12	700	8,400	203	177	<10	631	631
24-inch-diameter steel pipe in dewatered cofferdam*	12	700	8,400	193	167	<10	136	136
* In-water pile d with an attenuation device, such as a bubble curtain, would be similar.								

Based on these parameters, the peak sound level will not be expected to exceed the interim injury threshold criteria of 206 dB_{peak}. The $SEL_{cumulative}$ is dependent on the source single-strike SEL and the number of pile strikes in a day. Figure 5.H.6-1 illustrates the attenuation of $SEL_{cumulative}$ to the 187 dB and 183 dB interim criteria for a number of sheet pile driving scenarios ranging from 5 strikes to 8,000 strikes in a day. However, under the assumed worst case scenario of 12 piles impact-driven in a day, with a source sound level of 180 dB single-strike SEL and 700 strikes per sheet pile (8,400 strikes in a day), $SEL_{cumulative}$ levels will exceed both the 183 dB $SEL_{cumulative}$ (for fish smaller than 2 grams) and 187 dB $SEL_{cumulative}$ criteria (for fish larger than 2 grams) out to a distance of approximately 1,000 meters (3,280 feet) from the pile being driven. For comparison, if only two sheet piles were impact-driven in a day (1,000 strikes), the distance to the 187 dB $SEL_{cumulative}$ criteria will be reduced to approximately 320 meters (about 1,050 feet).

In order to construct the cofferdams within one in-water work window, exceedance of these criteria over some distance of the river likely will be unavoidable if extensive impact driving is required. There are no effective methods to attenuate sound from impact driving of sheet piles because the sheets need to be interlaced, and individual sheets cannot be isolated by casings or air bubble rings as they are driven. Cofferdam installations also typically require some king (support) piles to support the sheet-pile walls, particularly at the corners. These support piles are expected to produce lower sound pressure levels than the sheet piles and are included in the estimate of up to 12 piles driven per day and 700 pile strikes per pile. Therefore, the estimates calculated above for the sheet-pile installation also apply to these other in-water pile driving activities.

5.H.6.1.2.2 Intake and Pumping Plant Foundation Pile Installations

After the cofferdam is constructed and dewatered, foundation piles will be installed to support the intakes and pumping plant. As noted earlier, these piles will be CIDH piles, which do not require pile driving (only drilling), or 24-inch-diameter steel pipe piles that are driven then filled with concrete. It is anticipated that if piles are driven they will be primarily vibrated. However, as with the sheet-pile installation, some of these foundation piles may require impact driving.

Project engineers estimate that 8 to 12 foundation piles could be driven per day, with up to 700 strikes per pile. Impact driving of 24-inch-diameter steel pipe piles in water would result in single-strike sound levels of 203 dB_{peak} and 177 dB SEL at 10 meters (California Department of Transportation 2009). These sound levels are expected to be attenuated by about 10 dB for piles driven inside a dewatered cofferdam, or with a bubble curtain or other similar device, resulting in single-strike sound levels of 193 dB_{peak} and 167 dB SEL. Assuming an additional attenuation rate of 4.5 dB per doubling of distance, the maximum distance within which the cumulative effects threshold criteria would likely be exceeded is about 136 meters (about 450 feet) from the impact pile driving locations (see Table 5.H.6-1 and Figure 5.H.6-2). This distance is shorter than the estimated width of the river at the three intake sites (between about 535 and 645 feet wide), likely providing some refuge area on the opposite side of the river for fish rearing and migration (see Table 5.H.6-3). During periods of vibratory pile driving or when fewer impact pile strikes are needed, the size of this refuge area will be greater (see Figure 5.H.6-2). Installing CIDH piles for the foundation will eliminate or substantially minimize pile driving activities and potential underwater noise level effects on fish.

No methods other than the attenuation provided by the dewatered cofferdam could be used to attenuate the sound further. In order to proceed with the construction, foundation piles could be driven at various times of the year, not just within the in-water work windows, so the potential for all the covered fish species to be exposed to increased sound levels is greater than for cofferdam sheet-pile installations, which will occur when fewer covered species are likely to be present.

Construction schedule projections assume that 12 piles could be installed at each intake site during each 8-hour work day. Measures described in *AMM9 Underwater Sound Control and Abatement Plan* (Appendix 3.C, *Avoidance and Minimization Measures*) specify that the construction contractor will use vibratory pile driving to the greatest extent practicable, switching to an impact hammer only when necessitated by site-specific geotechnical conditions. Vibratory noise will not be continuous. The hammer will be turned off to attach and position the next pile and, when necessary, to position and attach the impact hammer. These hammer-off activities typically require a minimum of 10 to 20 minutes per pile, possibly longer. However, multiple pile drivers may be operated at each intake location and they will not operate synchronously, so periods of effective quiet may be shorter.

Impact pile driving will be far more limited in duration. Referring to the assumptions detailed in Section 5.H.5.1.1, the number of pile strikes per pile is estimated at 700 and 12 piles are expected to be installed in any given day at an intake location. Assuming a pile strike interval of 1.5 seconds (typical for most impact hammer configurations), this equates to 12.5 minutes of pile driving per pile and a maximum of about 150 minutes of impact pile driving per day at each location. As noted in Section 5.H.5.1.1, it is estimated that impact pile driving will be required only 30% of the time during the in-water work window (approximately 50 days total). This equates to a maximum of 125 total hours of impact pile driving across all intake locations over the course of an entire 151-day annual work window.

5.H.6.1.2.3 Barge Landing Pile Installations

For the barge landings, up to 36 24-inch-diameter steel pipe piles will be needed to support the temporary docks at each of the six landings to provide service to the tunnel portals. These will be similar to the foundation piles described above, except driven in the water. Although predominantly vibratory methods will be used to drive these piles, geologic conditions at the sites are not known at this time, and some piles may require impact driving.

Impact driving of the steel pipe piles in water is anticipated to result in single-strike sound levels of 203 dB_{peak} and 177 dB SEL at 10 meters (California Department of Transportation 2009). Therefore, the injury threshold criteria of 206 dB_{peak} will not be exceeded. As with the other pile installations, project engineers estimate that up to 12 piles could be driven per day, with up to 700 strikes per pile. Assuming the same attenuation rate of 4.5 dB per doubling of distance, the $SEL_{cumulative}$ criteria are predicted to be exceeded over a distance of about 631 meters (2,070 feet) from the pile driving locations (see Table 5.H.6-1 and Figure 5.H.6-3). If an attenuation device is used (e.g., isolation casing, bubble curtain), the source sound levels are assumed to be attenuated by 10 dB (193 dB_{peak} and 167 dB SEL at 10 meters). Therefore, the $SEL_{cumulative}$ criteria are predicted to be exceeded out to about 136 meters (450 feet) from the pile driving location (see Table 5.H.6-1 and Figure 5.H.6-2). Unlike the intake sites, however, this distance would extend across the entire width of the waterways, providing no potential refuge areas while impact pile driving is occurring.

5.H.6.1.2.4 Sound Effects Evaluation

As discussed above, vibratory pile driving is generally accepted as an effective mitigation measure for minimizing or eliminating detrimental effects of pile driving on fish, as the resulting sound levels are not expected to cause injury to fish. However, vibratory driving can result in noninjurious effects on fish (modification of behavior). These fish may respond by avoiding the immediate vicinity during active vibratory driving, altering their migratory pathways, or changing territorial and foraging behavior. This potentially could expose individuals to increased predation risk, but this effect is not documented and therefore difficult to quantify.

While temporary migration delay is possible, there is little evidence that fish will significantly alter their migratory behavior in response to elevated underwater noise. Larval and juvenile fish species that are transported by currents will not be able to alter their behavior sufficiently to change the rate of migration through the affected area. Migratory adult and large juvenile salmonids or other fish species conceivably could respond to sound stressors, but available evidence suggests a significant migration delay is unlikely. For example, Carlson (1996) observed salmon and steelhead responses to vibratory pile driving in the Columbia River and found that avoidance responses typically were limited to exposure within 6 to 9 meters of the pile. He concluded that, because of the short range of this effect, vibratory pile driving is unlikely to have a significant effect on the migration behavior of juvenile salmonids. Similarly, Feist et al. (1992) observed juvenile salmonid migratory behavior in nearshore marine habitats in proximity to impact pile driving. They found that schools of juveniles exposed to pile driving noise exhibited initial startle responses but did not move offshore or measurably alter their migratory behavior. They also appeared to habituate to noise relatively quickly. This suggests that any migratory delay resulting from underwater noise exposure will be brief (minutes rather than hours) and most likely will occur relatively close to pile driving activity. Additionally, as described earlier, pile driving will occur intermittently through the 8-hour workday and therefore may not affect migration behavior during non–pile driving periods.

Should impact driving of piles be required (it is assumed, based on construction of Freeport intakes, that approximately 30% of the piles will be impact-driven), fish in the vicinity of the intake and barge landing sites on days when impact driving occurs could be exposed to underwater noise levels exceeding the $SEL_{cumulative}$ interim threshold criteria. However, data show that the peak sound level criteria will not be exceeded based on the pile size/type assumed for this project. Figure 5.H.6-4 shows the locations of the intakes and barge landings in the Delta subregions. Table 5.H.6-2 illustrates the potential for presence of covered species (by life history stage) in the areas of the Delta where the intakes (North Delta subregion) and the barge landing sites (East and South Delta subregions) are located. Table 5.H.6-3 indicates the approximate area of water bodies exposed to underwater sound levels exceeding 183 dB $SEL_{cumulative}$.

Pile	24-inch AZ steel sheet pile							
Peak (dB) at 10 m	205							
Single Strike SEL (dB) at 10 m	180							
Distance (m) to 150 dB SEL	1000							
Attenuation Factor	15							
Number of Strikes Per Day	5	50	100	500	1000	2000	4000	8000
Distance from Pile (m)								
10	187	197	200	207	210	213	216	219
20	182	192	195	202	205	208	212	215
40	178	188	191	198	201	204	207	210
80	173	183	186	193	196	199	202	205
160	169	179	182	189	192	195	198	201
320	164	174	177	184	187	190	193	196
640	160	170	173	180	183	186	189	192
1000	157	167	170	177	180	183	186	189

Source Data: Table I.2-1 (Caltrans 2009). Attenuation of 4.5 dB per doubling of distance assumed.

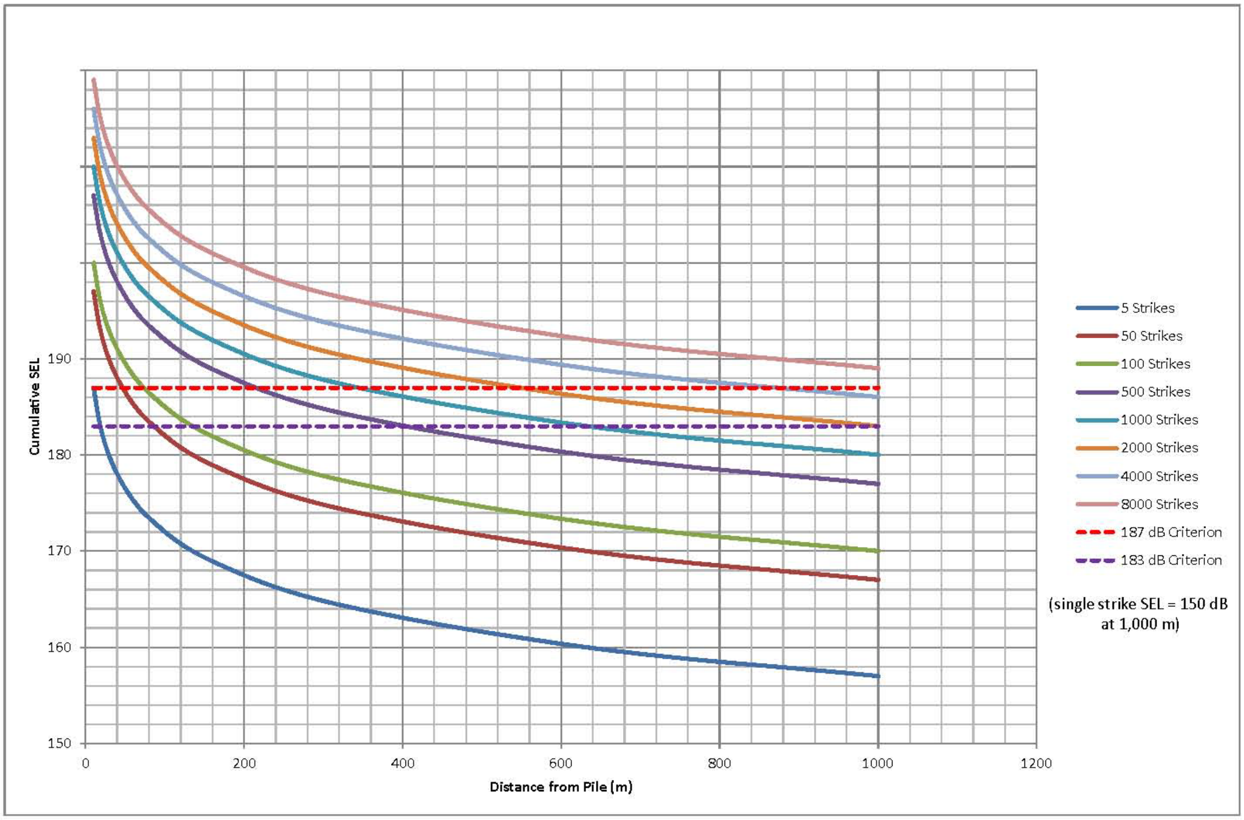

Figure 5.H.6-1. Sheet Pile Impact Driving (Single Strike SEL = 180 dB at 10 m)

Pile	24-inch steel pipe pile in dewatered cofferdam	(assumes 10 dB attenuation from dewatered cofferdam)						
Peak (dB) at 10 m	193							
Single Strike SEL	167							
Distance (m) to 150 dB SEL	136							
Attenuation Factor	15							
Number of Strikes Per Day	5	50	100	500	1000	2000	4000	8000
Distance from Pile (m)								
10	174	184	187	194	197	200	203	206
20	169	179	182	189	192	195	199	202
40	165	175	178	185	188	191	194	197
80	160	170	173	180	183	186	189	192
100	159	169	172	179	182	185	188	191
120	158	168	171	178	181	184	187	190
130	157	167	170	177	180	183	186	189
140	157	167	170	177	180	183	186	189

Source Data: Table I.2-1 (Caltrans 2009). Attenuation of 4.5 dB per doubling of distance assumed.

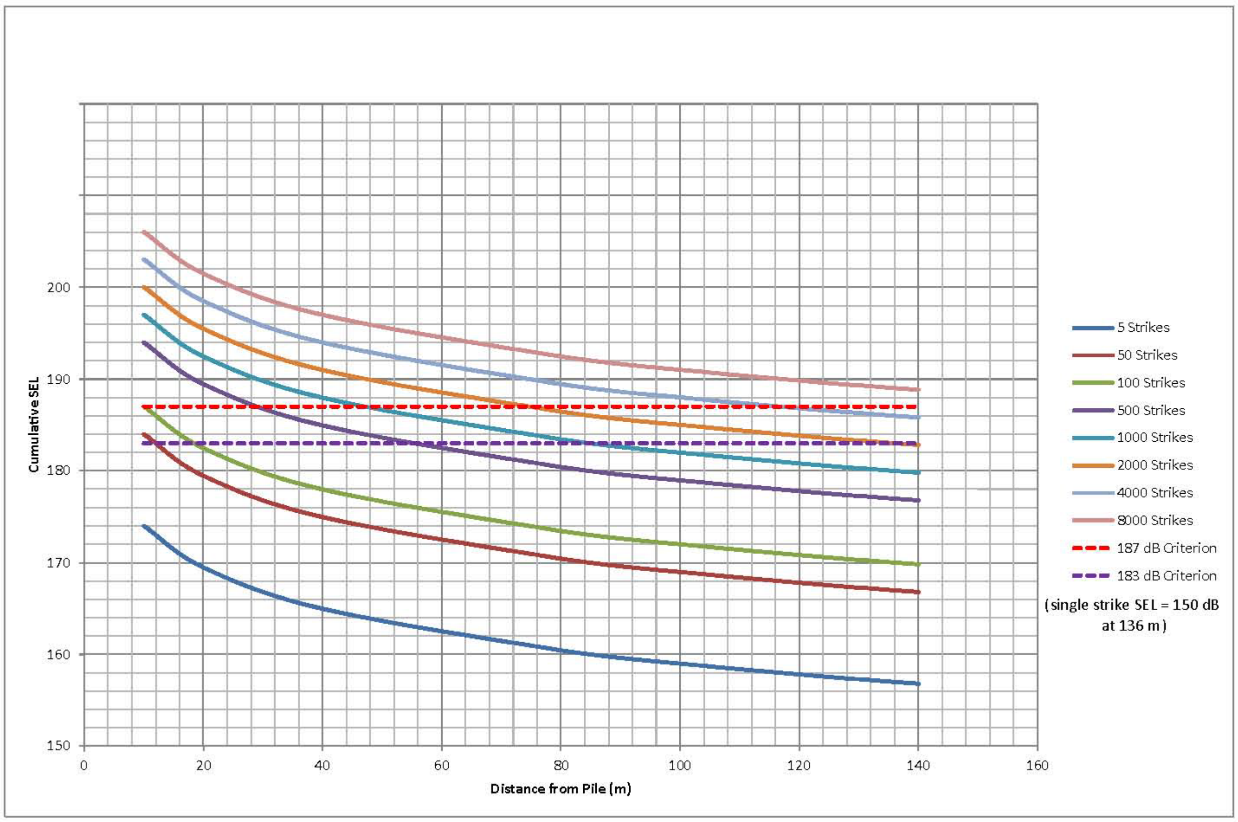

Figure 5.H.6-2. 24-Inch Steel Pipe Pile in Dewatered Cofferdam Impact Driving (Single Strike SEL = 167 dB at 10 m)

Pile	24-inch steel pipe pile							
Peak (dB) at 10 m	203							
Single Strike SEL	177							
Distance (m) to 150 dB SEL	631							
Attenuation Factor	15							
Number of Strikes Per Day	5	50	100	500	1000	2000	4000	8000
Distance from Pile (m)								
10	184	194	197	204	207	210	213	216
20	179	189	192	199	202	205	209	212
40	175	185	188	195	198	201	204	207
80	170	180	183	190	193	196	199	202
160	166	176	179	186	189	192	195	198
320	161	171	174	181	184	187	190	193
480	159	169	172	179	182	185	188	191
640	157	167	170	177	180	183	186	189

Source Data: Table I.2-1 (Caltrans 2009). Attenuation of 4.5 dB per doubling of distance assumed.

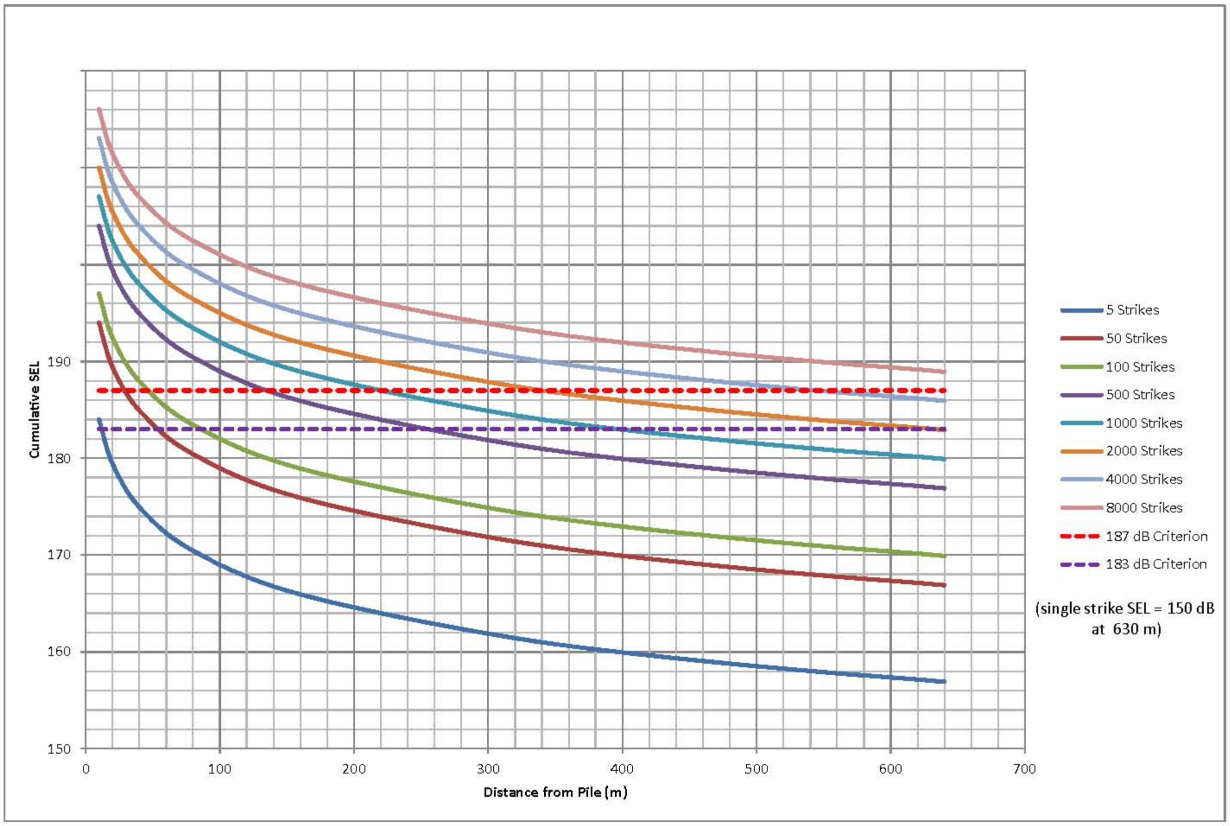

Figure 5.H.6-3. 24-Inch Steel Pipe Pile Impact Driving (Single Strike SEL = 177 dB at 10 m)

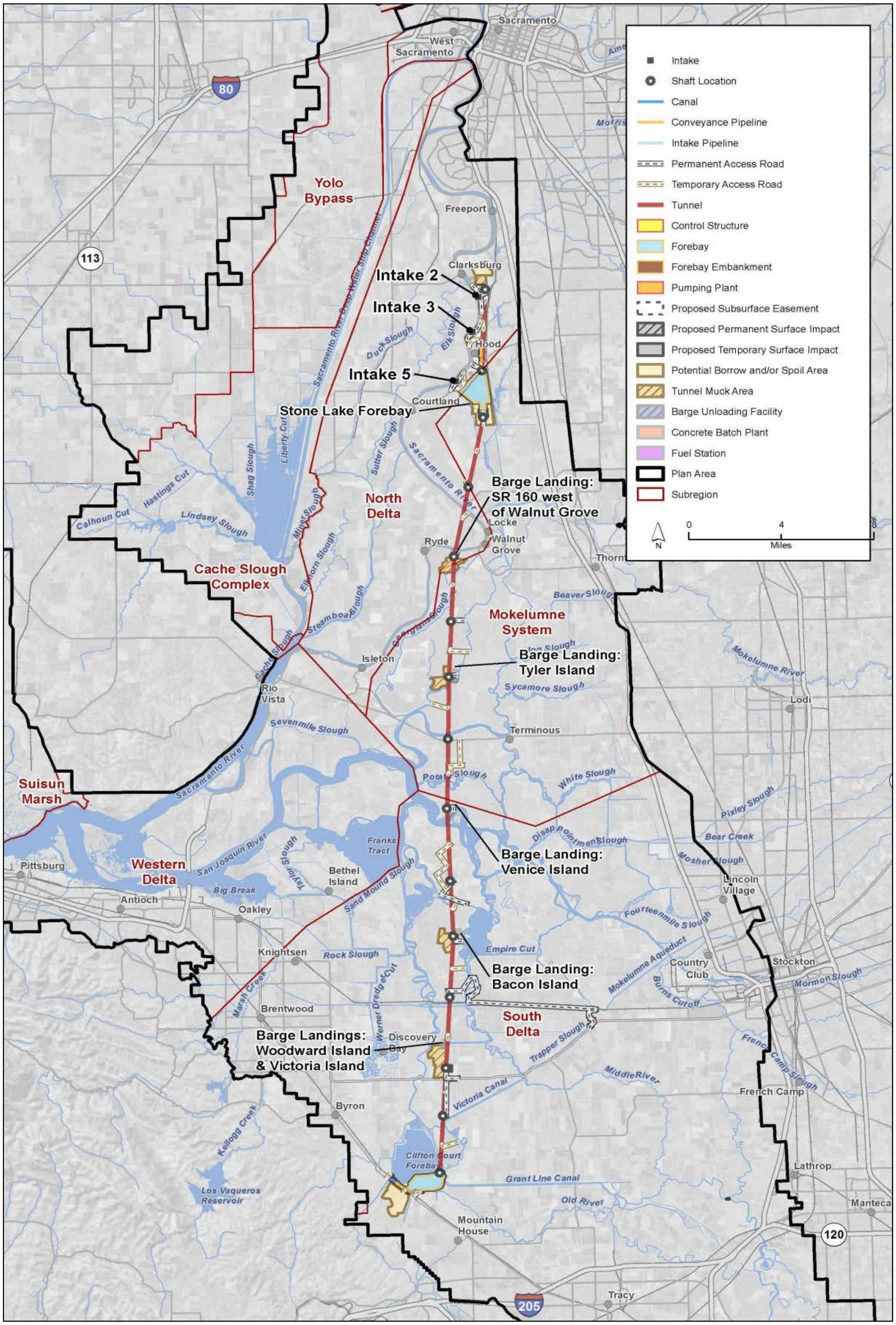

Figure 5.H.6-4. Tunnel Option Intake and Barge Landing Locations

Table 5.H.6-2. Life Stages of Covered Species Present in the North, East and South Delta Subregions during the In-Water Construction Window (June 1–October 31)

Fish Species	North Delta			East Delta			South Delta		
	Life Stage	Timing	Size	Life Stage	Timing	Size	Life Stage	Timing	Size
Delta smelt[1]	Adult	Jun	>2g	Adult	Jun	>2g	Adult	Jun	>2g
	Larva	Jun–Jul	<2g	Larva	Jun–Jul	<2g	Larva	Jun–Jul	<2g
Longfin smelt[2]	Adult	Not Present	>2g	Adult	Not Present	>2g	Adult	Not Present	>2g
	Larva	Not Present	<2g	Larva	Not Present	<2g	Larva	Not Present	<2g
Central Valley steelhead[3]	Adult	Jun-Sept Oct	>2g	Adult	Not Present	>2g	Adult	Not Present	>2g
	Juvenile	Jun-Oct	>2g	Juvenile	Jun-Oct	>2g	Juvenile	Jun-Oct	>2g
Winter-run Chinook salmon[4]	Adult	Jun-Jul	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Aug-Oct	<2g, >2g	Juvenile	Not Present	<2, >2	Juvenile	Not Present	<2, >2
Spring-run Chinook salmon[5]	Adult	Jun Jul-Aug	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g
Late fall–run Chinook salmon[6]	Adult	Oct	>2g	Adult	Oct	>2g	Adult	Oct	>2g
	Juvenile	Jun-Oct	>2g	Juvenile	Jun-Oct	>2g	Juvenile	Jun-Oct	>2g
Fall-run Chinook salmon[7]	Adult	Aug-Sep –Oct	>2g	Adult	Aug-Sep –Oct	>2g	Adult	Aug-Sep –Oct	>2g
	Juvenile	Jun	>2g	Juvenile	Not Present	<2g, >2g	Juvenile	Not Present	<2g, >2g
Splittail[8]	Larva	Jun	<2g	Larva	Jun	<2g	Larva	Jun	<2g
	Juvenile	Jun–Jul	<2g	Juvenile	Jun–Jul	<2g	Juvenile	Jun–Jul	<2g
Green sturgeon[9]	Adult	Jun-Oct	>2g	Adult	Jun-Oct	>2g	Adult	Jun-Oct	>2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
White sturgeon[10]	Adult	Jun-Oct	>2g		Jun-Oct		Adult	Jun-Oct	>2g
	Larva	Jun	<2g	Larva	Jun	<2g	Larva	Jun	<2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
Pacific lamprey[11]	Adult	Jun–Aug	>2g	Adult	Jun–Aug	>2g	Adult	Jun–Aug	>2g
	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g
River lamprey[12]	Adult	Sep–Oct	>2g	Adult	Sep–Oct	>2g	Adult	Sep–Oct	>2g
	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g

Fish Species	North Delta			East Delta			South Delta		
	Life Stage	Timing	Size	Life Stage	Timing	Size	Life Stage	Timing	Size
	Macropthalmia	Jun–Jul	>2g	Macropthalmia	Jun–Jul	>2g	Macropthalmia	Jun–Jul	>2g

Green=abundant[13]		Orange=semi-abundant		Yellow=low abundance		White=not likely or uncertain presence	

Sources:

[1] Bennett 2005; Baxter et al. 2008; California Department of Fish and Game 2007; Moyle et al. 1992; Nobriga and Herbold 2009; Sommer et al. 2011.

[2] Rosenfield 2010; Hieb and Baxter 1993; Baxter 1999a; Dege and Brown 2004; Bennett et al. 2002; Moyle 2002; Hobbs et al. 2006; Rosenfield and Baxter 2007; Feyrer et al. 2003.

[3] Hallock et al. 1961; McEwan 2001; California Department of Fish and Game 1995; Hallock et al. 1957 based on limited unpublished data from DFG Steelhead Report Card; California Department of Fish and Game unpublished data; Snider and Titus 2000; Nobriga and Cadrett 2003; Jones & Stokes Associates, Inc. 2002; S.P. Cramer and Associates, Inc. 2000, 2001; Schaffter 1980.

[4] Yoshiyama et al. 1998; Moyle 2002; Myers et al. 1998; Martin et al. 2001; Snider and Titus 2000; U.S. Fish and Wildlife Service 2006.

[5] Yoshiyama et al. 1998; Moyle 2002; Myers et al. 1998; Lindley et al. 2006; California Department of Fish and Game 1998; McReynolds et al. 2005; Ward et al. 2002, 2003; Snider and Titus 2000; U.S. Fish and Wildlife Service 2001.

[6] State Water Project and Federal Water Project fish salvage data 1981–1988. Yoshiyama et al. 1998; Moyle 2002; Martin et al. 2001; U.S. Fish and Wildlife Service 2001.

[7] State Water Project and Federal Water Project fish salvage data 1981–1988. Yoshiyama et al. 1998; Moyle 2002; Martin et al. 2001; U.S. Fish and Wildlife Service 2001.

[8] Baerwald 2007; Moyle et al. 2004; Feyrer et al. 2005; Crain et al. 2004; T. Ford pers. comm.; T. Heyne pers. comm.; M. Horvath pers. comm.; Baxter 1999b; Sommer et al. 1997; Caywood 1974; Meng and Matern 2001; Daniels and Moyle 1983; Sommer et al. 2001; Feyrer and Baxter 1998; Kratville 2008.

[9] U.S. Fish and Wildlife Service 2002a; Moyle et al. 1992; Adams et al. 2002; National Marine Fisheries Service 2005a; Kelly et al. 2007; California Department of Fish and Game 2002; BDAT fall midwater trawl green sturgeon captures from 1969 to 2003; Nakamoto et al. 1995; Heublein et al. 2006.

[10] Moyle 2002; Surface Water Resources 2004; Welch et al. 2006; PSMFC 1996; Kolhorst 1976; Wang 1986; Israel et al. 2009.

[11] Morrow 1980; Moyle 2002; Brown and Moyle 1993; Streif 2008; Ruiz-Campos and Gonzalez-Guzman 1996; Renaud 2008; Swift et al. 1993; Roffe and Mate 1984.

[12] Moyle 2002; Vladykov and Follett 1958; Moyle et al. 1995; Beamish and Youson 1987; Beamish and Neville 1995; Streif 2008.

Table 5.H.6-3. Length, Width, and Area of Water Bodies Potentially Exposed to Underwater Sound Levels above 183 dB SELcumulative If In-Water Impact Pile Driving Is Required

Intake or Barge Landing	Length of Water Body Experiencing Underwater Sound Levels above 183 dB $SEL_{cumulative}$ (feet)	Width of Water Body Experiencing Underwater Sound Levels above 183 dB $SEL_{cumulative}$ (feet) [3]	Area of Water Body Experiencing Underwater Sound Levels above 183 dB $SEL_{cumulative}$ (square feet [acres])	Potential Timeframe of Exposure[4]
Intake 2	6,560 [1]	645	4,231,200 [97 acres]	
Intake 3	6,560 [1]	560	3,673,600 [84 acres]	
Intake 5	6,560 [1]	535	3,509,600 [91 acres]	
Walnut Grove Landing	906 [2]	300	271,800 [6.2 acres]	
Tyler Island Landing	906 [2]	400	362,400 [8.3 acres]	
Venice Island Landing	906 [2]	150	135,900 [3.1 acres]	
Bacon Island Landing	906 [2]	350	317,100 [7.3 acres]	
Woodward Island Landing	906 [2]	380	344,280 [7.9 acres]	
Victoria Island Landing	906 [2]	380	344,280 [7.9 acres]	

Notes:

[1] Based on NMFS model—the single-strike SEL for impact cofferdam pile driving will attenuate to 150 dB (which is not considered to harmfully accumulate) at 1,000 meters (3,280 feet); thus the maximum distance (upstream plus downstream combined) that will be exposed to 183 dB $SEL_{cumulative}$ will be 3,280 feet upstream and downstream, for a total of 6,560 feet.

[2] Based on NMFS model—for 24-inch-diameter impact pile driving with 10 dB attenuation provided by a bubble curtain or a dewatered cofferdam, the single-strike SEL will attenuate to 150 dB (which is not considered to harmfully accumulate) at 138 meters (453 feet); thus the maximum distance (upstream plus downstream combined) that will be exposed to 183 dB SELcumulative will be 906 feet.

[3] Listed widths represent the entire river cross sections at these sites.

[4] Site-specific conditions will dictate the actual need and timeframe for vibratory and/or impact pile driving.

Impact pile driving could result in injury to fish near the pile driving location, depending on proximity and duration of exposure. In-water pile driving at the intakes will occur during the first year of construction during the approved in-water construction window (typically June through October). Table 5.H.6-4 summarizes the duration of potential exposure to underwater sound during impact pile driving for the species that are present between June and October. These estimates amount to an equivalent of 6 days of impact pile driving per month (30% of 20 work days/month). This is considered a worst-case scenario because impact pile driving will not occur continuously on any given day and is unlikely to occur at all of the construction sites at the same time.

After the cofferdams are completed during the first in-water work window, subsequent pile driving will occur inside the dewatered cofferdams, or inside a bubble curtain or similar device to minimize underwater sound levels. This will minimize, but not eliminate, potential effects on the covered species. Pile driving inside a cofferdam, or on land adjacent to a water body, can transmit sound through the substrate and into adjacent water bodies, a process known as flanking. Under certain circumstances these sound pressure levels transmitted into the water are sufficient to cause injuries to fish. As this subsequent pile driving also will occur throughout most of the year, there is the potential to affect a greater proportion of the covered species populations, particularly those species that migrate past the intake sites outside of the in-water construction window.

As indicated above, impact pile driving within a dewatered cofferdam is expected to attenuate the sound levels in the adjacent waterbody by about 10 dB (see Table 5.H.6-1). This is similar to the attenuation likely to occur using a bubble curtain, or other similar device, during in-water pile driving. Applying this attenuation level to the expected sound pressure levels from impact driving 24-inch-diameter hollow steel piles likely would result in sound levels that could affect fish within about 136 meters (450 feet) of the cofferdam. However, the river channel adjacent to the intakes is wider than 450 feet, resulting in potential refuge areas along the opposite side of the river.

There is no substantial evidence that pile driving noise causes substantial migration delays, and migration speeds tend to be relatively fast for both adult and juvenile fish (Del Real et al. 2011; Holbrook et al. 2009; Heublein et al. 2008; Parsley et al. 2008; Vogel 2010). These studies observed typical migration speeds greater than 0.4 mile per hour. While there are a large number of factors that influence migrations, it is reasonable to expect that many migratory fish are likely to pass the sites in a matter of hours, substantially minimizing their exposure to elevated underwater sound levels. The potential for covered species exposure is described in the following subsections.

Table 5.H.6-4. Species Present and Estimated Duration of Exposure to Impact Pile Driving during Cofferdam Installation, Assuming That Impact Pile Driving Is Necessary for 30% of the Piles

Species/Life Stage Present	Lifestage and Month(s) Present in Areas Affected by Underwater Sound during Cofferdam Installation[1]	Duration of Potential Exposure (days)[2]
Delta smelt[3]	Adults—June Larvae—June, July	6 12
Steelhead	Adults—June through Oct Juveniles—June through Oct	30 30
Chinook salmon (winter-run)	Adults—June/July Juveniles—Aug through Oct	12 18
Chinook salmon (spring-run)	Adults—June through Aug	18
Chinook salmon (late fall–run)	Adults—Oct Juveniles—June through Oct	6 30
Chinook salmon (fall-run)	Adults—Aug through Oct Juveniles—June	18 6
Sacramento splittail	Larvae—June Juveniles—June/July	6 12
Green sturgeon	Adults—June through Oct Juveniles—June through Oct	30 30
White sturgeon	Adults—June through Oct Juveniles—June through Oct Larvae—June	30 30 6
Pacific lamprey	Adults—June through Aug Ammocoetes—June through Oct	18 30
River lamprey	Adults—Sept/Oct Ammocoetes—June through Oct Macropthalmia—June/July	12 30 12

[1] For the barge unloading facilities, if it is assumed that installing the piles at each site requires 10 days, each site might experience 3 days of impact driving (and potential effects). All species except winter- and late fall–run Chinook salmon could be present during construction of the barge unloading facilities.

[2] Assumes that 30% of pile driving is impact driving during period of species presence and assumes 5 days per week of work, for a total of 20 work days per month.

[3] Low densities of delta smelt are expected to occur in the pile driving areas during these exposure periods

5.H.6.1.2.5 Delta Smelt

Delta smelt eggs will not experience underwater sound because the locations of the intakes and barge landings are not considered suitable habitat for this life stage of this species; therefore, effects will not occur.

There is a very small potential for adult or larval delta smelt to be in the vicinity of the intakes and the barge landing sites during in-water construction (in June and between June and July, respectively). Delta smelt tend to occupy the western Delta subregion and will be in very low abundance in the North, East and South Delta subregions during this time; therefore, fish densities in areas affected by pile driving will be exceedingly low. Adult delta smelt complete their spawning cycle and die by mid- to late June. Larval delta smelt, which move with the currents, potentially could drift through the underwater sound–affected area(s); however, their distribution during this time is predominantly in the western Delta, rather than the northern and southern Delta where the intake pile driving could occur. If an individual larval delta smelt were present in the areas affected by underwater sound from pile driving above 183 dB $SEL_{cumulative}$, it could experience an adverse effect, such as injury or mortality. Because the density of larval delta smelt is expected to be exceptionally low in all pile driving locations, the potential for delta smelt to experience an adverse effect (e.g., injury or mortality) is very low.

5.H.6.1.2.6 Longfin Smelt

Longfin smelt eggs will not experience underwater sound because the locations of the intakes and barge landings are not considered suitable habitat for the life stage of this species; therefore, effects will not occur.

Similar to delta smelt, there is a very small potential for juvenile longfin smelt to be in the vicinity of the intakes and all barge landing sites during in-water construction (in June). Longfin smelt will be in very low abundance in the North, East and South Delta subregions during the construction periods, and densities in areas potentially affected by pile driving will be very low. Larval longfin smelt, which move with the currents, potentially could drift through the underwater sound–affected areas; however, their distribution is predominantly located in the western Delta, rather than the northern and southern Delta where the intake pile driving will occur. If an individual larval longfin smelt were present in the areas ensonified by pile driving above 183 dB $SEL_{cumulative}$, it could experience an adverse effect, such as injury or mortality. Because the overall densities of larval longfin smelt are expected to be exceptionally low in all pile driving locations, the potential for longfin smelt to experience an adverse effect (e.g., injury or mortality) will be very low.

5.H.6.1.2.7 Central Valley Steelhead

Central Valley steelhead eggs and fry will not experience underwater sound from pile driving because the locations of the intakes and barge landings are not considered suitable habitat for these two life stages of this species; therefore, effects will not occur.

Adult Central Valley steelhead could be present near the construction areas of the intakes and barge landings during the June to October in-water construction window. Adults use the Sacramento and San Joaquin Rivers on their migration to upriver spawning areas during the summer, fall and winter months, although densities are expected to be low through the spring and summer months. Steelhead will have a moderate abundance near the construction areas for intakes in September and October. Adult steelhead are large and are able to avoid injurious exposure to underwater noise from pile driving. They may experience short delays in migration past the intakes when pile driving is occurring; however, pile driving will occur only intermittently through 8 hours per day, and minor migration delays will not affect their ability to successfully reach spawning grounds. Therefore, the potential for adult Central Valley steelhead to experience an adverse effect (e.g., injury or mortality, migratory disturbance) is low because of their size, ability to move away from the underwater sound, and potentially low to moderate temporal and spatial migration distribution around the construction areas.

Juvenile steelhead that have migrated downriver could be moderately abundant in the vicinity of the intakes and barge landing sites during June, although they are known to emigrate during most months of the year (Hallock et al. 1961). The habitat in these areas is considered poor because of relatively steep riprap banks and deep channels with little refuge, which may limit their overall abundance in these areas. Although it is not possible to predict the number of steelhead that will be exposed to underwater sound at the construction locations, underwater noise could exceed the criteria for approximately 8 hours a day for 30 days at each intake during the in-water construction window. Underwater sound also could exceed the criteria for approximately 5 days for barge landing construction activities. Therefore, individual juvenile steelhead present could be injured or killed if the exposures are great enough[6]. There will be a moderate potential for juvenile Central Valley steelhead to experience an adverse effect (e.g., injury or mortality, migratory disturbance) because of their size, ability to move away from the underwater sound source, moderate temporal and spatial distribution around the construction sites, and the intermittent nature of potential exposure above the tolerance thresholds.

5.H.6.1.2.8 Winter-Run Chinook Salmon

Winter-run Chinook salmon eggs and alevins will not experience underwater sound because the locations of the intakes and barge landings are not considered suitable habitat for these two life stages of this species, and they will not be present during the in-water construction period (June through October); therefore, effects will not occur. Winter-run Chinook salmon fry, although not numerous, do occur in August through October, although the majority of the fry migrate in late November and December (Snider and Titus 2000).Adult winter-run Chinook salmon could be present near the intake construction areas during the in-water work window and will likely be affected by construction activities. Adult winter-run Chinook salmon are large and have the mobility to avoid injurious exposure to underwater noise from pile driving. They may experience short delays in migration past the intakes when pile driving is occurring; however, pile driving will occur only intermittently through 8 hours per day, and minor migration delays will not affect their ability to successfully reach spawning grounds. Therefore, underwater sound has a low potential of affecting adult winter-run Chinook salmon because of their size, ability to move away from exposure, and potentially low temporal and spatial distribution during construction periods.

Juvenile winter-run Chinook salmon will be in low abundance during in-water construction periods in the North Delta subregion in September and October. The density of juvenile winter-run Chinook salmon near the specific intake and barge landing sites is unknown; however, the habitat in these areas is considered poor because of relatively steep riprap banks and deep channels with little refuge, which may limit their overall abundance in these areas. Although juveniles could occur around the intakes in October, there will be a relatively low potential for juvenile winter-run Chinook salmon to experience an adverse effect (e.g., injury or mortality, migratory disturbance) because of the intermittent nature of potential exposure above the tolerance thresholds.

5.H.6.1.2.9 Spring-Run Chinook Salmon

Spring-run Chinook salmon eggs and fry will not experience underwater sound because the locations of the intakes and barge landings are not considered suitable habitat for these two life stages of this species, and they will not be present during the in-water construction period (June through October); therefore, effects will not occur. Likewise, juvenile spring-run Chinook salmon are unlikely to occur near the intakes or barge landings during the in-water construction period (June through October). Therefore, little or no effects will occur on juvenile spring-run Chinook salmon as a result of underwater sound. Adult spring-run Chinook salmon will have a moderate potential to be in the North Delta subregion in June and a low potential to be in the North Delta subregion in July

[6] As identified under *Methods*, NMFS model assumes that a fish is stationary within the impact area throughout the entire exposure (a day of pile driving).

during intake construction activities. Adults use the Sacramento River to migrate to upriver spawning areas. Adults will not occur near the barge landings in the eastern and southern subregions. Adult spring-run Chinook salmon are large and have the mobility to avoid injurious exposure to underwater noise from pile driving. They may experience short delays in migration past the intakes when pile driving is occurring; however, pile driving will occur only intermittently through 8 hours per day, and minor migration delays will not affect their ability to successfully reach spawning grounds. Therefore, the potential for adult spring-run Chinook salmon to experience an adverse effect (e.g., injury or mortality, migratory disturbance) is low because of their size, ability to move away from the underwater sound, and potentially low to moderate temporal and spatial migration distribution around the intake construction areas.

5.H.6.1.2.10 Late Fall-Run Chinook Salmon

Late fall-run Chinook salmon eggs and fry will not experience underwater sound because the locations of the intakes and barge landings are not considered suitable habitat for these two life stages of this species, and they will not be present during construction timeframes (June through October); therefore, effects will not occur.

Adult late fall-run Chinook salmon will not occur near the intakes or barge landing sites during the in-water construction period (June through October). Therefore, no effects will occur on adult late fall-run Chinook salmon as a result of underwater sound.

Juvenile late fall-run Chinook salmon greater than 2 grams have a very low potential to occur near the intakes and barge landing sites throughout the June through October period. Additionally, the habitat in these areas is considered poor because of relatively steep riprap banks and deep channels with little refuge, which may further limit their overall abundance. Therefore, the potential for juvenile late fall-run Chinook salmon to experience an adverse effect (e.g., injury or mortality, migratory disturbance) is low because of the very low temporal and spatial migration distribution around the intake and barge landing construction areas, and the intermittent nature of potential exposure above the tolerance thresholds.

5.H.6.1.2.11 Fall-Run Chinook Salmon

Fall-run Chinook salmon eggs and fry will not experience underwater sound because the locations of the intakes and barge landings are not considered suitable habitat for these two life stages of this species, and they will not be present during construction timeframes (June through October); therefore, effects will not occur.

Adult fall-run Chinook salmon are expected to be semi-abundant to abundant near the construction areas of the intakes and barge landing sites in August through October. Adults use the Sacramento River and pass by the construction areas on their migration to upriver spawning areas. Adult fall-run Chinook salmon are large and have the mobility to avoid injurious exposure to underwater noise from pile driving. They may experience short delays in migration past the intakes and barge landings when pile driving is occurring; however, pile driving will occur only intermittently through 8 hours per day, and minor migration delays will not affect their ability to successfully reach spawning grounds. Therefore, the potential for adult fall-run Chinook salmon to experience an adverse effect (e.g., injury or mortality, migratory disturbance) is low because of their size, ability to move away from the underwater sound, and potentially low temporal and spatial migration distribution around the construction areas.

Juvenile fall-run Chinook salmon have a low to moderate potential to occur near the intakes and barge landing sites during pile driving in June. The density of juvenile fall-run Chinook salmon near the specific intake and barge landing sites during the in-water construction period is unknown. However, the habitat in these areas is considered poor because of relatively steep riprap banks and deep channels with little refuge, which may further limit their overall low to moderate abundance. Given their low numbers in the eastern and southern subregions, the relatively small areas affected by underwater noise, and the intermittent nature of the impact pile driving, there is only a small chance fall-run Chinook salmon will be exposed at the barge landings. Therefore, the potential for juvenile fall-run Chinook salmon to experience an adverse effect (e.g., injury or mortality, migratory disturbance) is low because of potentially low to moderate temporal and spatial distribution during construction and because potential exposure above the tolerance thresholds will be intermittent and limited.

5.H.6.1.2.12 Splittail

Larval splittail could occur in the vicinity of the intakes in June, and juvenile splittail could be in the vicinity of these sites in June and July during the in-water construction period. The numbers of larval and juvenile splittail are not known, but abundance is expected to be very low during these months because they are typically not present in the north, east, or south Delta. Larval and juvenile splittail near the construction areas will be expected to be less than 2 grams and will move with the currents. The potential for splittail to be exposed to pile driving noise will be relatively small, given the location of the intakes in the Sacramento River, the relatively small areas affected by underwater noise in the East and South Delta subregions. Therefore, the potential for larval and juvenile splittail to experience an adverse effect (e.g., injury or mortality) is low because of their very low temporal and spatial distribution during construction and intermittent and limited potential exposure above the tolerance thresholds.

5.H.6.1.2.13 Green Sturgeon

Green sturgeon eggs and larvae will not experience underwater sound because the locations of the intakes and barge landings are not considered suitable habitat for these two life stages of this species and they will not be present during construction timeframes (June through October); therefore, effects will not occur. The habitat at the intake sites is of relatively poor condition, with steep riprap-armored banks and limited in-water or overwater habitat features typically associated with rearing habitat. As a result, these river reaches are expected to be used primarily as migratory corridors, reducing the duration of potential exposures of green sturgeon to increased underwater sound levels.

Adult green sturgeon could occur near the intakes during pile driving primarily during June, which is at the tail end of their upstream spawning migration but also could occur throughout the in-water construction period as they migrate downstream after spawning. However, they will not be present near the barge landing sites as they are typically not present in the East and South Delta subregions. Adult green sturgeon are large and are able to avoid injurious exposure to underwater noise from pile driving. They may experience short delays in migration past the intakes when pile driving occurs; however, pile driving will occur only intermittently through 8 hours per day, and minor migration delays will not affect their ability to successfully reach spawning grounds. Therefore, the potential for adult green sturgeon to experience an adverse effect (e.g., injury or mortality, migratory disturbance) is low because of their size, ability to move away from the underwater sound, and potentially low temporal and spatial distribution during construction. Furthermore, potential exposure of green sturgeon to underwater sound above the tolerance thresholds will be intermittent and limited.

While juvenile green sturgeon may be exposed to elevated sound levels from pile driving and other construction activities, the primary use of a vibratory pile driving hammer, the relatively poor habitat conditions at the construction sites, and the intermittent nature of potential exposures to underwater sound levels above the tolerance thresholds likely would limit the overall effects on juvenile green sturgeon. Therefore, the potential for juvenile green sturgeon to experience an adverse effect (e.g., injury or mortality) is relatively low.

5.H.6.1.2.14 White Sturgeon

As indicated above for green sturgeon, the habitat at the intake sites is of relatively poor condition, with steep riprap-armored banks and limited in-water or overwater habitat features typically associated with rearing habitat. As a result, these river reaches are expected to be used primarily as migratory corridors, reducing the duration of potential exposures of white sturgeon to increased underwater sound levels.

Adult white sturgeon could occur near the intakes during pile driving primarily during June, as they migrate upriver to spawn but also could occur throughout the in-water construction period as they migrate back downstream after spawning. Adults also could occur near the barge landing in the South Delta subregion in June. Adult white sturgeon are large and are able to avoid injurious exposure to underwater noise from pile driving. They may experience short delays in migration past the intakes when pile driving is occurring; however, pile driving will occur only intermittently through 8 hours per day, and minor migration delays will not affect their ability to successfully reach spawning grounds. Therefore, the potential for adverse effects on adult white sturgeon as a result of underwater sound is low.

Similar to green sturgeon, juvenile white sturgeon may be exposed to elevated sound levels from pile driving and other construction activities. However, the primary use of vibratory pile driving, the relatively poor habitat conditions at the construction sites, and the intermittent nature of potential exposures to underwater sound levels above the tolerance thresholds likely would limit the overall effects on juvenile green sturgeon. Therefore, the potential for juvenile green sturgeon to experience an adverse effect (e.g., injury or mortality) is relatively low.

5.H.6.1.2.15 Pacific Lamprey

Adult lamprey and their ammocoetes could be present in the vicinity of the intakes and barge landings during pile driving during June–August and June–October, respectively. However, ammocoetes are in low abundance at all in-water pile driving sites. Adults are considered moderately abundant in June through August near the intakes, but are in low abundance in the East and South Delta subregions where barge landings are located. Adult lamprey are large and are able to avoid injurious exposure to underwater noise from pile driving. Given their likely low numbers in the East and South Delta subregions, the relatively small areas affected by underwater noise in the those areas, and the intermittent nature of potential exposure above the tolerance thresholds, there is only a small chance that adult lamprey or their ammocoetes will be exposed to injurious underwater sounds from pile driving at the barge landings. Although adults will be moderately abundant in June through August near the intakes, their size and ability to move away from the underwater sound in the northern Delta will result in a low potential for adverse effects as a result of underwater sound.

Most of the other potential effects are expected to occur during the installation of the cofferdams, when lamprey could be entrapped within the cofferdam. This is likely to be a one-time occurrence because the cofferdams allow the majority of the other remaining construction activities to occur in the dry, thereby minimizing additional effects. In addition, fish rescue and salvage operations will be conducted to remove fish before and during the cofferdam dewatering phase (see Appendix 3.C, *Avoidance and Minimization Measures*). The effectiveness of these procedures will be evaluated during the process and modified if necessary to minimize effects on Pacific lamprey.

5.H.6.1.2.16 River Lamprey

Adult lamprey and macropthalmia stages could be present in the vicinity of the intakes and barge landings during pile driving during September–October and June–July, respectively. Ammocoetes can occur throughout the year, as they remain in the substrate for several years before metamorphosis to the macropthalmia stage when they migrate to the ocean. The density of adult lamprey, ammocoetes and macropthalmia near the specific intake and barge landing sites during the in-water construction period is unknown, but densities are expected to be low in all areas where in-water work will occur. Given their likely low numbers in the North, East and South Delta subregions, the relatively small areas affected by underwater noise compared to available habitat, and the intermittent nature of potential exposure above the tolerance thresholds, there is only a small chance that this species will be exposed to injurious underwater sounds from pile driving. Therefore, there is low potential for adverse effects to occur on river lamprey as a result of underwater sound.

As indicated above for Pacific lamprey, most of the potential effects likely will occur during construction of the cofferdams, allowing the other construction activities to occur in the dry. The potential occurrence of river lamprey in these areas will be evaluated during the cofferdam dewatering and fish salvage and rescue operations, and appropriate measures will be implemented to minimize potential effects on river lamprey.

5.H.6.1.3 Water Quality

The majority of the intake construction will occur within the channel and channel banks behind a cofferdam. Therefore, any water quality effects of *CM1 Water Facilities and Operation* will be minimal during construction. Constructing the conveyance facilities will intersect a large number of agricultural ditches and drains and may require in-water construction at certain slough crossings, but this is also likely to have minimal effects on water quality because *CM22 Avoidance and Minimization Measures* establishes BMPs to result in minimal water quality effects. The potential effects of turbidity and suspension of potentially toxic sediments and accidental spills associated with these activities are described below.

5.H.6.1.3.1 Turbidity

As indicated in Table 5.H.2-1 and Table 5.H.2-2, cofferdam installation at the intakes and pile driving at the barge landings will disturb bottom sediments and could result in turbidity levels that could affect covered fish species. In-water construction activities that could generate increased turbidity are not continuous. Sheet pile driving for the cofferdams will occur during an approximately 8-hour period each day for up to 5 months (during the in-water work window). In-water work associated with constructing the barge landings could take several weeks but will be confined to 8-hour periods each work day.

While some in-water construction activities will result in unavoidable turbidity effects, the extent of these effects will be minimized by limiting the duration of in-water construction activities, through the implementation of *CM22 Avoidance and Minimization Measures*, and by adhering to measures described in the Central Valley Regional Water Quality Control Board's *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (Basin Plan). These environmental commitments were developed to meet the expected conditions required by environmental permits issued by state, federal, and local agencies. Turbidity and other water quality parameters will be monitored throughout the construction period to ensure compliance with these commitments. In the event that any criteria thresholds are exceeded, all turbidity-producing activities will be slowed or halted until levels subside and/or appropriate corrective measures are taken. Following is a list of turbidity limits that will be upheld throughout all construction activities.

- Where natural turbidity is between 0 and 5 NTUs, increases will not exceed 1 NTU.
- Where natural turbidity is between 5 and 50 NTUs, increases will not exceed 20%.
- Where natural turbidity is between 50 and 100 NTUs, increases will not exceed 10 NTUs.
- Where natural turbidity is greater than 100 NTUs, increases will not exceed 10%.

In general, in the Delta the turbidity is often 20–40 NTUs and decreases to less than 10 NTUs during low-flow conditions. Turbidity increases in the rivers during high flows (to 250–500 NTUs) and turbidity is generally elevated in Suisun Bay (measurements of 50–100 NTUs common) as a result of tidal resuspension. For reference regarding covered fish species, elevated turbidity levels can have a negative effect on fish, but moderate levels of turbidity (e.g., 35–150 NTUs) can increase foraging rates, presumably in response to reduced vulnerability to sight-feeding predators (Gregory and Northcote 1993). However the effects vary by species and their turbidity tolerance levels.

In-water activities will be monitored per the measures described in *CM22 Avoidance and Minimization Measures*, and the Basin Plan to ensure that the turbidity limits are not exceeded. Generally, if in-water activities resulted in turbidity levels that approached these limits, the activity will be slowed so that turbidity can be maintained at levels in compliance with these limitations.

In-water construction activities will have minimal effects on covered fish species. The expected increases in turbidity and suspended sediment will be of short duration, limited in extent, and monitored for compliance with regulatory standards. In addition, any localized increases in suspended sediment and turbidity likely will be diluted quickly as a result of the mixing potential associated with channel currents. Potential effects on covered fish species likely will be limited to indirect effects resulting from the behavioral response of fish to turbid water and suspended sediment in the affected portion of aquatic habitats. Such responses include avoidance of high turbidity, changes in foraging ability, increased predation risk, and reduced territoriality (Meehan and Bjornn 1991; Bash et al. 2001). However, most increases in turbidity and suspended sediment will occur during approved work windows in the summer period when fewer individuals of migratory species (e.g., Chinook salmon, steelhead, splittail, sturgeon) are likely to be present in the south Delta (River Islands).

5.H.6.1.3.2 Toxins

As discussed in Section 5.H.5.1.2, *Water Quality*, toxic substances are present in both water and sediment in the Delta aquatic environment. In-water construction activities will result in suspension of sediments that may contain toxic contaminants.

A discussion of the available sediment chemical data and the factors that will determine the potential for impacts from toxins in sediments during *CM1 Water Facilities and Operation* construction and maintenance activities is presented below. This discussion includes the fate and transport characteristics and conceptual models for each of the chemicals, as presented in Appendix 5.D, *Contaminants*.

The three water intakes will be located in the Sacramento River, downstream of the main urban area of the city of Sacramento. Sediments at these locations could be affected by historical and current urban discharges from the city of Sacramento. Of the urban-related toxic constituents identified in Appendix 5.D, metals (lead and copper), hydrocarbons, organochlorine pesticides, and PCBs are common urban contaminants with the greatest affinity for sediments and potentially could be present in sediments that will be disturbed during installation of the cofferdams. In addition, mercury is present in the Sacramento River system and could be sequestered in bottom sediments. The barge landings will be constructed on smaller waterways and are more likely to have agriculture-related toxins, including copper and organochlorine pesticides.

Turbidity, and in turn suspension of sediments, will be minimized by the measures in *CM22 Avoidance and Minimization Measures*, and adhering to the requirements of the Basin Plan to minimize turbidity during construction. Additionally, exposure of covered fish species to any disturbed contaminated sediments will be minimized by restrictions on in-water work that will be limited to between June 1 and October 31, when the potential for many of the covered species to be present in the vicinity of construction will be at a minimum. Although sturgeon are assumed to be potentially present year-round and therefore could be affected by water quality, they are bottom feeders so will eat the toxins with or without construction occurring; therefore, effects are considered low.

Regulatory requirements identified in Table 5.H.4-1 and the avoidance and minimization measures included in *CM22 Avoidance and Minimization Measures* will minimize suspension of bottom sediments and restrict the construction schedule so that construction activities do not coincide with the presence of sensitive or abundant species/life stages; there is a low probability of negative effects on covered fish species from disturbance of toxic contaminants in bottom sediments during construction.

5.H.6.1.3.3 Spills

Because the in-water construction periods for *CM1 Water Facilities and Operation* will be short-term (approximately 5 months) for both the cofferdams at the intakes and the piles at the barge landings, and the in-water construction equipment will be limited to barges and pile driving equipment, the potential for direct accidental spills to the aquatic environment is short-term and will be for spills of very limited quantities. The most likely types of accidental spills will be fuel, oil, and hydraulic fluids. These types of spills are readily contained by booms, and all personnel will be trained to identify and rapidly respond to such accidents, as further described in the following paragraph. There will be potential for spills in upland areas or behind the cofferdam to flow into the aquatic system, but the probability of these types of impacts is also low, given the spill prevention and response programs described below.

Implementation of the *CM22 Avoidance and Minimization Measures* will reduce the potential for introduction of contaminants to surface waters and provide for effective containment and cleanup should accidental spills occur. The avoidance and minimization measures that establish BMPs to minimize potential effects of accidental spills on covered species include those below.

- Preparation and implementation of a SWPPP, as described in Appendix 3.C, *Avoidance and Minimization Measures*, and conditions of the project NPDES permit.
- Preparation and implementation of a hazardous materials management plan before beginning construction.
- Preparation and implementation of a spill prevention and control plan.
- Training to inform all field management and construction personnel of the need to protect resources.

5.H.6.1.4 Habitat Modification

In-water construction will disturb on-bank channel habitat and in-river benthic and pelagic habitat in the vicinity of the construction activities. These activities will include construction of cofferdams, channel dredging, levee removal, bank protection removal and installation, and overwater structures (barge landings).

The affected habitat associated with the intake facilities is currently armored levee bank with limited riparian vegetation and of generally low value for species rearing. Cofferdams will be used to isolate the entire work area from the wetted channel of the Sacramento River during construction of each of the three intake facilities. At each of the intakes, between 1.6 and 3.1 acres of river area will be temporarily isolated by the cofferdams during the entire construction period, for a total of up to about 7.5 acres for all three intakes combined (Table 5.H.3-1).

Existing channel margin conditions at the intake sites were summarized using the Sacramento River Bank Protection Project revetment database (U.S. Army Corps of Engineers 2007). Revetment database surveys from a research vessel characterized channel margin segments with relatively homogenous habitat features. A more detailed discussion of the database is provided in Appendix 5.E, *Habitat Restoration*. The database covers levees that are part of the Sacramento River Flood Control Project and includes information relative to aquatic habitat, such as water depth, emergent vegetation, and the amount of overhead cover (shade provided primarily by riparian vegetation) occurring along the channel margin. However, the water depth information extends only up to 12 feet from the shoreline, measured from the mean summer water level elevation (U.S. Fish and Wildlife Service 2002b), while the intakes typically extend about 50 feet or more from shore.

The estimated length of shoreline temporarily and permanently modified by the intake structures is identified in Table 5.H.6-5 and Table 5.H.6-6, respectively. These tables also summarize the shoreline habitat characteristics in these affected areas. Because of the relatively steep armored banks, the depth range category of 5–10 feet (based on the revetment database) typically occurs within 12 feet of the shoreline. Most of the armored levee shoreline habitat that will be temporarily affected during construction consists of relatively sparse overhead cover. About 98% of the shorelines at the intake sites have less than about 25% overhead cover, and about 18% of the shorelines have only 1% to 5% overhead cover (Table 5.H.6-5). In addition, there is virtually no emergent vegetation in these steep-banked shoreline areas. The limited overhead and in-water cover and typically steep-banked and riprapped shorelines limit the quality of the fish rearing habitat in the area. A total of about 1.1 miles of this habitat may be temporarily affected during construction.

Table 5.H.6-5. Temporary Channel Habitat Modification (Miles)

Intake	5–10 Feet Deep at a Distance of 12 Feet*	2.5 Feet Deep at a Distance of 5 Feet	<2.5 Feet Deep at a Distance of 5 Feet	Emergent Vegetation	Overhead Cover				Total Bank Line Affected*
					0%	1–5%	6–25%	26–75%	
Intake 2	0.1	0.2	0.1	0	0	0.2	0.1	0	0.3
Intake 3	0.6	0.6	0	0	0	0	0.6	0	0.6
Intake 5	0.2	0.2	0	0	0	0	0.2	0.03	0.2
Total	0.9	1.0	0.1	0	0	0.2	0.9	0.03	1.1

Units are miles.
Numbers may not add in the table because of rounding.
* The depth 12 feet from shore is nearly always 5–10 feet; therefore, the total in the first column is generally the same as the final column.

As with the temporary effects, most of the bank habitat that will be permanently lost is armored levee bank, which will be replaced by the intake structures. Some riparian trees and shrubs that grow on the levee banks will be lost, slightly reducing instream cover and shade and the contribution of leaves, small debris, and insects falling into the river from overhanging vegetation. However, bank armoring and lack of physical structure currently limit the quality of this kind of habitat. A total of up to about 2.6 miles of riverbank will be permanently affected (see Table 5.H.6-6). As with the area of temporary effects, nearly all (96 %) of the permanently affected shoreline at the three intakes has less than about 25% overhead cover. The proportion of the permanently affected area with 6% to 25% overhead cover (about 85% of the affected shoreline) is similar to the areas temporarily affected. About 25% of the shoreline at Intake 2 is classified as having no overhead cover. The nearshore water depths at Intake 2 also are generally shallower than the other intakes, with 93% of permanently affected nearshore area (within 5 feet of the shoreline) less than 2.5 feet deep (see Table 5.H.6-6).

CM4 Tidal Natural Communities Restoration, CM6 Channel Margin Enhancement, and *CM7 Riparian Natural Communities Restoration* are expected to more than offset the losses resulting from temporary and permanent channel habitat modifications. Habitat restoration completed under the conservation measures will occur at various times throughout the life of the project. *CM4 Tidal Natural Communities Restoration* will provide substantially more rearing and spawning habitat for delta smelt and Sacramento splittail by restoring 65,000 acres of tidal habitat. This restoration will be implemented incrementally, with the first 4,000 acres restored immediately after BDCP authorization. Implementation of *CM6 Channel Margin Enhancement* will be phased, with 5 miles of enhancement completed by year 10 and an additional 5 miles completed by each of years 20, 25, and 30, for a total of 20 miles of enhanced channel margin. This channel margin enhancement is designed to improve habitat function in the north Delta along important migratory and rearing routes. Actions under *CM7 Riparian Natural Community Restoration* also will be phased, with 2,300 acres restored by year 15, and 5,000 (cumulative) acres restored by year 40.

Table 5.H.6-6. Permanent Channel Habitat Modifications (Miles)

Intakes	5–10 Feet Deep at a Distance of 12 Feet	2.5 Feet Deep at a Distance of 5 Feet	<2.5 Feet Deep at a Distance of 5 feet	Emergent Vegetation	Overhead Cover 0%	Overhead Cover 1–5%	Overhead Cover 6–25%	Overhead Cover 26–75%	Total Bank Line Affected
Intake 2	1.08	0.9	1.1	0	0.3	0.1	0.8	0	1.2
Intake 3	0.8	0.8	0	0	0	0	0.8	0	0.8
Intake 5	0.6	0.6	0	0	0	0	0.6	0.1	0.6
Total	2.5	2.3	1.1	0	0.3	0.1	2.2	0.1	2.6

Units are miles.
Numbers may not add in the table due to rounding.
* The depth 12 feet from shore is typically 5–10 feet; therefore, the total in the first column is the generally the same as the final column.

5.H.6.1.4.1 Potential Habitat Modification Effects on Covered Fish Species

Habitat modification will result from direct impacts associated with the intake and barge landing in-water and on-bank construction. The loss or modification of habitat could result in species displacement. Loss or modification of spawning, rearing, and migrating habitat, as well as the loss or change of the benthic communities that covered species use as food sources are discussed below.

Spawning Habitat

Permanent loss of delta smelt and Sacramento splittail spawning habitat could occur as a result of the construction activities at the three intakes. There is no suitable spawning habitat in the vicinity of the proposed in-water work for any other covered species; therefore, no spawning habitat of other covered fish species is expected to be affected.

Rearing Habitat

Permanent loss of low-value rearing habitat will occur where the existing riverbanks and streambed will be replaced with permanent in-water structures. Construction and channel dredging will permanently alter up to about 2.6 miles of channel margin (see Table 5.H.6-6), including a total of about 1.2 miles of permanent cofferdam and intake structures (see Table 5.H.4-1). These structures will convert relatively steep-banked riprap shoreline to vertical walls, further reducing the quality of the rearing habitat in the area. The remainder of the 2.6 miles of permanent effects will consist primarily of replacing or adding riprap to existing levee habitat. In addition, about 5.1 acres of in-water habitat will be permanently lost and replaced by the intake structures, and about 14.6 acres will be temporarily affected by construction activities or dredging. All the juvenile covered fish likely use these habitat areas, particularly the channel margin, and may be affected by the changes. However, these affected areas represent a small fraction of the total rearing habitat occurring in the Plan Area, and were of low value to begin with.

Migration Habitat

Cofferdams will isolate the work areas, temporarily reducing the width of the Sacramento River available to fish for migration, although not enough to prevent fish passage for any of the covered fish species. However, the intakes typically will replace sloped armored shoreline habitat with a similarly artificial shoreline, except that it will be vertical and in deeper water. The intakes will have transition walls that gradually extend from the shoreline out to the offshore limit of the intake structure, rather than a wall perpendicular to the shoreline. These transition walls will be constructed at both the upstream and downstream ends of the intake to minimize potential effects on migrating fish. While the gradual transitions will minimize the potential creation of predator holding areas adjacent to the intakes, juvenile migrants may be forced to follow a path through deeper-water habitat, potentially increasing the risks of predation. Surface-oriented larval or juvenile fish are believed to be at greater risk from predation when forced or diverted to deeper water areas that provide less protection from larger predators than shallow water shoreline habitat. Although, the riprap armored shorelines that will be replaced already provide similar deep water shoreline habitat, they also provide areas between the rocks as potential refuge from predators. Additionally, construction of the intakes will result in a permanent loss of approximately 2.6 miles of salmon rearing and migration channel margin habitat[7]. Implementation of *CM6 Channel Margin Enhancement* will enhance 20 miles of the Sacramento River, including the vicinity of the intake structures, to provide an overall improvement in channel margin habitat function.

Benthic Habitat

Construction and channel dredging will temporarily disturb benthic habitat. Benthic organism removal from dredging, and burying deposit feeders, suspension/deposit feeders, and suspension feeders, will occur in portions of the dredged area. Removing these organisms through dredging or disposal may cause short-term effects on fish species residing in the dredge area by limiting food resources. In addition, barge operations have the potential to affect bottom sediments and benthic habitat through propeller wash effects. This is most relevant in the vicinity of the barge landings and in narrow channels where tugboats will be close to the channel bottom and have the potential to stir up bottom sediments and submerged aquatic vegetation, potentially resulting in a temporary disturbance of rearing habitat. Tugboat and barge speed in the narrow channels will be low enough that vessel wakes are not expected to affect shoreline habitat.

Benthic substrate that is excavated contains macroinvertebrates that provide prey for covered fish species. Covered fish species that consume benthic macroinvertebrates include white and green sturgeon and Sacramento splittail. This could result in reduced growth of sturgeon and splittail. As discussed above, only a very small area of total habitat will be affected initially and the work will be conducted in stages. During construction, up to about 7.5 acres of in-water habitat will be isolated by the cofferdams, and up to an additional 12.1 acres of substrate habitat will be affected by dredging or filling activities, for a total of 19.6 acres of habitat temporarily or permanently affected by intake construction. Cofferdam construction activities will occur for 2 to 5 months at each of the three intake locations.

Because sturgeon and splittail are expected to be in low abundance in the construction areas and there is other habitat in the immediate vicinity available for foraging, effects will be minor and temporary. After dredging, there is potential for nonnative invertebrates to colonize the area before native invertebrates. Invertebrates are dependent on site conditions (depth, substrate, salinity, velocity) and if they are not changed drastically, there should be no change in invertebrate populations. Invertebrates are expected to recolonize dredge locations within months; therefore, potential long-term impacts on fish associated with these activities are expected to be small. Moreover, the areas of dredging and deposition at any one time are small fractions of the total area

[7] Federally designated as critical habitat.

of the Sacramento River. Thus, the influx of organisms from the surrounding undisturbed areas can be rapid.

Cover Habitat

In-water pilings and docks installed at barge landings will increase cover habitat that may be used by predacious fish and contribute to additional predation on covered fish species, including juvenile Chinook salmon. Predacious fish may benefit most from structures that provide refuge from stream currents to rest and await smaller fish moving with the current. In addition, the proximity to natural current breaks and depth changes where predators naturally congregate could influence the effect of added structures, such as pilings and intakes, on predator behavior. Appendix 5.F, *Biological Stressors and Covered Fish,* includes additional analyses related to predation at the new intakes. Implementation of *CM15 Localized Reduction of Predatory Fishes* will include removing specific predator hotspots, targeted predator removal, and other focused methods to reduce predation on covered fish species. Furthermore, once the construction of the intakes and tunnel is complete, the barge landings will be removed and no longer provide cover habitat.

5.H.6.1.5 Physical Injury or Loss

5.H.6.1.5.1 Entrapment and Handling Stress

In-water work associated with facility construction may include the use of temporary barriers to buffer pile driving sound and limit the extent of turbidity. Using these temporary barriers has the potential to entrap fish. Where water depth is shallow, entrapped fish can be netted and removed from within the enclosed in-water work areas. Fish removal could result in handling stress and possibly in physical injuries incurred during capture and removal from the area. The risk of fish entrapment and subsequent handling stress during removal will be minimized by limiting in-water work to an approved time period (June 1 through October 31). However, because some use of the affected portion of the Sacramento River and Delta sloughs by covered species continues all year, there is the potential that some covered species could become trapped within temporary barriers.

Cofferdams will isolate the entire work area from the wetted channel during construction of the inlet facilities. Although fish likely will avoid the noise and activity of sheet-pile installation, cofferdams and temporary silt curtains have the potential to entrap fish. The number of fish potentially affected is unknown but could include a few hundred fish (total of all species) (Wones 2008a; Wones 2008b; Kelly et al. 2010), including some smaller numbers of juvenile Chinook salmon. The risk of fish entrapment and subsequent handling stress during removal will be minimized by limiting cofferdam construction and other in-water work to approved in-water work windows (June 1 through October 31) when Chinook salmon presence in the construction area will be at a minimum. However, because small numbers of juvenile Chinook salmon use the affected portion of the Sacramento River year-round, there is potential that some juvenile Chinook salmon could become trapped within temporary cofferdams when they are first installed.

Construction of conveyance facilities will intersect a large number of agricultural ditches and drains and may require in-water construction at certain slough crossings. In addition, construction of barge landings may require fish exclusion and removal from those areas to prevent injury from pile driving or other in-water construction activity associated with these structures. While the exact locations and methods of fish exclusions and removals are unknown, the in-water work associated with conveyance structures has the potential to affect fish in the waterways that are accessible to anadromous species. All of these effects could be minimized through development and implementation of a fish exclusion and relocation plan in coordination with the California Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, and NMFS.

5.H.6.2 Conservation Measures Focused on Restoration

5.H.6.2.1 Presence of Fish Species during Construction

The exact locations and timing of restoration construction activities are not known at this time, and therefore potential effects on particular fish species and habitats cannot be determined. However, Table 5.H.3-1 describes the potential for species to occur in each BDCP subregion. Restoration will be designed to avoid covered fish species and their habitat to the extent possible, including limiting construction activities in specific areas to times when covered fish are not present.

5.H.6.2.2 Water Quality

5.H.6.2.2.1 Erosion and Sedimentation

Restoration construction activities, such as levee construction, levee breaching, placement of riprap, dredging, and construction of dikes to maintain adjacent land uses could release sediments into restored areas. Increased levee erosion can occur along channel banks downstream of tidal breaches. Erosion also may result from the creation of new channels and altered drainage patterns. An increased tidal prism could contribute to erosion in sloughs, point bar formation in creeks, and sedimentation in channels. Increased erosion/sedimentation could disturb fish habitat temporarily and potentially injure bottom-oriented fish such as sturgeon and splittail. However, given the avoidance and minimization measures in the erosion and sedimentation control plan (see Appendix 3.C, *Avoidance and Minimization Measures*) and the temporary nature of restoration construction and maintenance activities, only minor and temporary increases in erosion and sedimentation are anticipated, thus making it unlikely that such effects will occur.

5.H.6.2.2.2 Turbidity

High turbidity can affect fish by decreasing foraging success, increasing predation risk, causing physical injury (e.g., clogging of gills), and reducing uptake of DO. Given the avoidance and minimization measures to control turbidity (see Appendix 3.C, *Avoidance and Minimization Measures*) and the temporary nature of restoration construction and maintenance activities, only minor and temporary increases in turbidity are anticipated, making it unlikely that such effects will occur. Turbidity levels will be monitored when sediment-disturbing activities are conducted, and such activities will be slowed or curtailed if the established limits on increasing turbidity are exceeded. These limits are based on water quality regulations that are assumed to be protective of fish and other aquatic species as described above (see also Appendix 3.C, *Avoidance and Minimization Measures*).

5.H.6.2.2.3 Toxins

Resuspension of toxins attached to sediments that are mobilized during dredging or levee repair potentially could impair fish behavior, development, growth, survival, and/or reproduction. Suspension of toxins into the water column is directly related to increased turbidity, which as discussed above under *CM1 Water Facilities and Operation*, is expected to be controlled.

5.H.6.2.2.4 Accidental Spills

Effects from accidental spills will be similar to those described for *CM1 Water Facilities and Operation*. Given the types of equipment used, any spills will be small, and any effects on fish species will be minor and temporary.

5.H.6.2.3 Habitat Modification

The realignment of Putah Creek under *CM2 Yolo Bypass Fisheries Enhancement* will permanently remove existing grassland, managed wetlands, and cultivated lands. Although this habitat modification will be permanent, it is designed to provide better habitat for covered fish species, including herbaceous riparian vegetation in the upstream half of the realignment and freshwater tidal marsh in the downstream half of the realignment. Therefore, the effects on covered fish species of construction activities related to the realignment are expected to be minor and temporary.

Under *CM4 Tidal Natural Communities Restoration*, construction of levees and breaching of levees to restore tidal flows could alter water salinity. Levee breaching also could result in temporary changes in channel hydraulics and flow velocities, depending on the size and location of the breach. Changes in salinity could temporarily disrupt fish passage or displace fish.

Construction activities that remove, or remove and replace, riprap may modify fish habitat temporarily by increasing sediment deposition and disturbing or removing cover. The installation of riprap typically will occur only in already armored shoreline areas to repair or maintain the structural integrity of the armor layer or to replace existing armoring. This includes areas near the proposed intakes, which is already armored, as well as replacing some shoreline armoring at levee setback sites. While riprap could be used for some restoration activities, restoration will increase the overall length and area of unarmored habitat and increase the amount of natural shoreline habitat.

Dredging may have a number of temporary effects on habitat. Dredging may increase channel depth and alter local hydraulics, temporarily impairing fish passage. Dredging may injure or kill benthic invertebrates, temporarily reducing forage for benthic feeding fish (sturgeon, splittail) and the quality of rearing habitat.

5.H.6.2.4 Physical Injury or Loss of Individuals

Dredging may disturb or remove bottom sediments, leading to physical injury or mortality of individual fish. Dredging also may injure or kill lamprey ammocoetes in bottom sediments. Activities such as placement and removal of riprap may increase sediment inputs and sediment deposition, resulting in fish injury or mortality. Injury and mortality can be minimized, however, by timing dredging and shoreline construction activities so that fish are uncommon or absent at the dredging site.

CM4 Tidal Natural Communities Restoration will include some conversion of nonvegetated areas to vegetated areas, potentially increasing the rate of mercury methylation, which can bioaccumulate through the foodweb to fish and humans. The effects of methylmercury are uncertain but potentially significant.

5.H.6.3 Other Conservation Measures

Many of the construction stressors and effects associated with other conservation measures will be similar to those described above for *CM1 Water Facilities and Operation* and restoration conservation measures (*CM2 Yolo Bypass Fisheries Enhancement*, CM4 *Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, *CM7 Riparian Natural Community Restoration*). The following subsections present results by conservation measure.

5.H.6.3.1 CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels

CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels construction activities include the construction of aeration facilities. Aeration facilities will be built above the ordinary high water mark on upland habitat. Installation of aeration devices in the channel may involve use of in-water equipment but is unlikely to involve impact or vibratory pile driving. This will require development of site-specific plans in consultation with the fish and wildlife agencies (U.S. Fish and Wildlife Service, NMFS, and California Department of Fish and Game). Aeration facility construction activities could occur at locations in the south Delta that have yet to be determined. At this time, specific locations have not been identified for aeration facilities. However, because the objective is to improve DO levels in the Stockton Deep Water Ship Channel, sites will be in locations that are not frequently used as habitat because of low DO levels by the covered species, particularly smelts, salmonids (Chinook salmon and steelhead), Sacramento splittail, white and green sturgeon, and lampreys.

5.H.6.3.1.1 Decrease in Water Quality

Turbidity and suspension of potentially toxic sediments associated with in-water structure construction will be similar to that described above for the north Delta intakes and restoration conservation measures. Local temporary increases in turbidity likely will cause juvenile salmonids to avoid the area during removal of structures and vessels and channel reconfiguration work. Juvenile salmonids have been shown to avoid areas of high turbidity, possibly because of reduced foraging ability.

5.H.6.3.1.2 Habitat Modification

Aeration facilities could modify nearshore bank habitat for covered species. Vegetation and tree cover could be removed to construct aeration facilities. In-channel aeration structures could modify habitat for covered species. However, the potential for adverse modifications to habitat used by covered species will be evaluated in the planning and consultation process for each individual location considered for habitat alterations in order to ensure that benefits of increased DO to covered species outweigh potential habitat losses. Installation of aeration structures ultimately will increase DO, which will benefit covered species that otherwise could be blocked from using habitat with low water quality.

5.H.6.3.2 CM15 Localized Reduction of Predatory Fishes

Construction activities under *CM15 Localized Reduction of Predatory Fishes* include removal of in-water structures and vessels and targeted fish removal activities (targeted predator removal effects are described in Appendix 5.F, *Biological Stressors and Covered Fish*). Removal of in-water structures likely will be achieved with barge-mounted cranes and equipment. Pilings and docks may be floated off or placed on barges and moved by tugboats. *CM15 Localized Reduction of Predatory Fishes* will require development of site-specific plans in consultation with the fish and wildlife agencies. This measure will be used only in locations that have been identified as hotspots for predators. At this time, specific locations have not been identified for structure removal, vessel removal, or modification of channel geometry. However, because the objective is to reduce opportunities for predation, sites will be in locations that are used frequently by the covered fish species, particularly smelts, juvenile salmonids, and Sacramento splittail, as identified in Table 5.H.2-2.

5.H.6.3.2.1 Underwater Sound

Removal of pilings or other underwater structures could involve use of vibratory methods. This could generate sounds that could cause avoidance behavior among any fish present. However, as discussed in Section 5.H.5.1.1, *Underwater Noise and Vibration*, the sound levels will not approach the peak or cumulative sound criteria or injure covered fish species. In addition, sound and vibration are expected to be short-term and temporary; generally, sound will be elevated for only a portion of a day for a few days at any given site.

Although noise and activity will not cause acoustic injury, it does have the potential to result in avoidance behavior among all fish species in the vicinity, including covered species.

Because of the low level of noise and activity, little to no direct injury to covered fish species is anticipated. Local temporary increases in turbidity likely will cause fish to avoid the area during removal of structures and vessels and channel reconfiguration work.

5.H.6.3.2.2 Decrease in Water Quality

Turbidity and suspension of potentially toxic sediments associated with pile removal and vessel removal will be similar to that described above for the north Delta intakes and restoration conservation measures and are summarized in Table 5.H.4-1. Local temporary increases in turbidity likely will cause juvenile salmonids, Sacramento splittail, adult smelt, adult and juvenile sturgeon, and adult and juvenile lamprey to avoid the area during removal of structures and vessels and channel reconfiguration work**.**

5.H.6.3.2.3 Habitat Modification

Habitat modifications to eliminate predator hiding locations will affect habitat for covered species. However, the potential for adverse modifications to habitat used by covered species will be evaluated in the planning and consultation process for each individual location considered for habitat alterations in order to ensure that benefits of reduced predation to covered species outweigh potential habitat losses. Placement of rock and other fill material potentially could bury benthic fishes. However, virtually all fish will be able to avoid the disturbance area and avoid injury.

Removal of structures and derelict vessels ultimately will reduce habitat for predatory fish species, which will benefit salmonids and smelt that otherwise are at risk of predation as they pass these structures during migration and rearing. However, removal will have little effect on sturgeon or lamprey, other than potentially slight indirect benefits for sturgeon and lamprey that feed on similar prey species.

5.H.6.3.3 CM16 Nonphysical Fish Barriers

CM16 Nonphysical Fish Barriers proposes to install nonphysical barriers at important channel junctions between October and June (or at times deemed appropriate by fishery agencies) to deter juvenile salmonids from migrating down waterways that have the potential for relatively low survival. The main locations that may be considered include the divergences of (1) Sacramento River and Georgiana Slough in the North Delta subregion, and (2) San Joaquin River and Old River in the South Delta subregion (the head of Old River). Additional locations in the South Delta subregion that may be considered for nonphysical barriers include the divergences of San Joaquin River with Turner and Columbia Cuts, and the entrances to the south Delta export facilities (Clifton Court Forebay and the Delta-Mendota Canal intake). Should nonphysical barriers be installed to deter delta smelt and longfin smelt from movement into the south Delta subregion, nonphysical barriers could be installed in the West Delta subregion at Threemile Slough and the mouths of Old and Middle Rivers.

Section 5H.2 and Table 5.H.2-2 describe species presence in the area that may be affected by the installation of nonphysical barriers.

5.H.6.3.3.1 Underwater Sound

The nonphysical barriers that have been tested in the Plan Area are temporary structures that are installed for a limited period of time and then removed and stored off site. The deterrent components of the barrier are mounted on frame segments that are attached to piles driven into the riverbed. The barrier components, including piles, will be removed at the end of the Chinook salmon migration season. Installation of nonphysical barriers under the BDCP may be similar to this 'total-removal' scenario or could include construction of permanent features (e.g., mounting structures on the riverbed that allow the nonphysical barrier to be installed on an annual basis without the need for annual pile driving). The discussion here generally assumes an installation and removal protocol similar to that used at Georgiana Slough and the head of Old River (full removal).

The underwater sound resulting from installing and removing the nonphysical barriers could cause additional avoidance behavior among any fish present. However, as discussed in Section 5.H.5.1.1, *Underwater Noise and Vibration*, the sound levels will not approach the peak or cumulative sound criteria or injure covered fish species. In addition, sound and vibration are expected to be short-term and temporary; generally, sound will be elevated for only a portion of a day for a few days at any given site.

5.H.6.3.3.2 Decrease in Water Quality

Local temporary increases in turbidity likely will cause covered fish species to avoid the area during removal of structures; however, this is expected to be short-term. *CM22 Avoidance and Minimization Measures* will include measures to ensure the increased turbidity is controlled and does not result in adverse effects on fish.

5.H.6.3.3.3 Habitat Modification

Impacts on the channel from installing or removing the nonphysical barriers will be minor; therefore, habitat modification is not expected.

5.H.6.3.4 CM21 Nonproject Diversions

CM21 Nonproject Diversions construction activities include removing or screening nonproject unscreened diversions. The project area includes approximately 2,589 nonproject diversions, many of which redirect water to nearby agricultural fields between April and August. The construction activities will involve equipment and activities similar to those described for other conservation measures in previous sections, such as the use of on-bank equipment to clear on-bank vegetation, dredging equipment to remove sediment around existing diversion pipes, and in-water work to place screens over existing diversion pipes. If existing smaller diversions are consolidated or a new diversion is constructed to replace multiple smaller ones, a cofferdam may be required as described in Section 5.H.4.1.3; this will require vibratory pile driving and dewatering as described in *CM1 Water Facilities and Operation* and Section 5.H.4.1.3. A dewatering plan for the cofferdam area will be developed as part of *CM 22 Avoidance and Minimization Measures* (see Appendix 3.C, *Avoidance and Minimization Measures*) and will address where to pump the water entrapped in the cofferdam. The dewatering plan also is intended to comply with federal Clean Water Act Section 401 and other applicable permit conditions. *CM 22 Avoidance and Minimization Measures* also includes a Fish Salvage and Rescue Plan that will be implemented during the cofferdam dewatering process to minimize potential effects on fish species in the area (see Appendix 3.C, *Avoidance and Minimization Measures*).

The nonproject diversions are concentrated in the Cache Slough area. The distribution, status, and biology of each covered species found in the area potentially can be affected by the remediation of nonproject-related diversions. All of the covered species associated with the BDCP occur in the Cache Slough area as identified by Table 5.H.2-2.

5.H.6.3.4.1 Underwater Sound

The underwater sound generated by consolidation of smaller unscreened diversions will be similar to that described above for *CM16 Nonphysical Fish Barriers*. Specifically, vibratory methods will be used to drive sheet piles into place to support a cofferdam. The construction likely will take place over several days to weeks in 8-hour work periods. The sound levels will not approach the peak or cumulative sound criteria or injure covered fish species. In addition, sound and vibration are expected to be short-term and temporary; generally sound will be elevated for only a portion of a day for a few days at a given site.

5.H.6.3.4.2 Water Quality

Construction-related activities will result in water quality impacts similar to those discussed for other conservation measures, including temporary, localized increases in turbidity and the potential for accidental spills. As previously discussed, implementation of *CM22 Avoidance and Minimization Measures* will result in a low probability of effects on water quality.

5.H.6.3.4.3 Habitat Modification

Construction-related activities have the potential to temporarily or permanently alter habitat conditions in the vicinity of nonproject diversions. During construction of the intake structures, dredging will occur that could modify existing benthic habitat used by aquatic covered species as food sources. However, the diversions are associated with habitat used by all covered fish species, so habitat benefits potentially accrue to all species once construction is complete. The relative benefits are likely to vary with respect to local abundance of each covered fish population, with larger benefits to larval and juvenile life stages that have low swimming velocity and/or a propensity to move with the flow vector.

5.H.7 Maintenance-Related Effects

Maintenance of the water conveyance facilities and restoration areas will result in potential stressors to aquatic species, similar to those described above for construction, but the magnitude of the effects will be less for maintenance activities. Therefore, these stressors are summarized below (underwater sound, water quality, changes in habitat, and direct loss of individuals). Differences are noted where they occur, and avoidance and minimization measures are included they relate to each stressor.

5.H.7.1 Underwater Sound

Maintenance of intake pumps may require the use of underwater divers, equipment, vessels, and barges to assess or fix problems with the intake pumps. This equipment may cause underwater sound. Maintenance of the restoration areas may include dredging equipment that could cause underwater sound. Because the powertrains for the dredges will be out of the water, underwater noise levels associated with these activities likely will be at 150 dB (RMS) or lower.

Noise levels produced by operations and maintenance activities are not expected to reach a level that will harm juvenile or adult fishes. Because most maintenance activities are anticipated to occur above water, the noise levels underwater will be much lower than those created in the air.

5.H.7.2 Water Quality

Increased turbidity could result from maintenance dredging, embankment maintenance, or other maintenance activities like cleaning fish screens that require instream work.

Although dredging could be needed to maintain channels in restoration areas or to remove sediment accumulation at the intakes, frequent maintenance dredging is not anticipated. Dredging operations disturb bottom sediments, resulting in increased turbidity and potential suspension of toxin-contaminated sediments in the water column where they can become more bioavailable to pelagic species. The following maintenance may be needed during the operational phase of the project.

- Suction dredging around intake structure using raft- or barge-mounted equipment and pumping sediment to a landside spoil area.
- Mechanical excavation around intake structures using track-mounted equipment and clamshell dragline from the top deck after installing a floating turbidity control curtain.
- Dewatering of intake/sedimentation basin/pumping plant bays to remove sediment buildup in conduits and channels using small front end–loading equipment and manual labor.

The same requirements that are discussed in previous sections for other in-water construction work also apply to dredging and other in-water maintenance activities (see Appendix 3.C, *Avoidance and Minimization Measures*). These activities will adhere to other water quality permits and the Basin Plan to maintain appropriate water quality conditions during construction. Work will be limited to periods when species abundance is low. Thus, effects on covered fish species will be minimal.

Effects of maintenance dredging will be similar to construction effects. Because turbidity and suspension of toxins into the water column are directly related, the restrictions on increased turbidity described above apply to toxins, and little increased exposure to covered fish species is expected.

Contaminant spills can occur during maintenance activities of intake pumps or maintenance dredging. Use of oil, gasoline, lubricants, or other fluids used for maintenance of intake pumps, fish screens, or equipment such as boats and barges can enter the water directly or by seepage. Protective spill prevention measures discussed in the construction section also apply to maintenance activities and result in a very low risk of effects on covered fish species.

The potential effects of decrease in water quality will be similar to those described above for effects associated with construction of facilities. However, they will be much shorter in duration and highly isolated to the actual facility or specific restoration area being maintained.

5.H.7.3 Habitat Modification

Two maintenance activities, dredging and riprap placement, will change and possibly reduce habitat values in the area around the intakes and levees. Although the areas around the intakes will already be modified permanently from construction of the intakes, further modifications related to maintenance, such as placement of additional riprap, could further deteriorate the quality of this area for rearing and migration. Benthic infauna are most vulnerable to dredging operations, although epibenthic and demersal species also are vulnerable (Nightingale and Simenstad 2001). Disturbed sites subsequently are expected to be recolonized, primarily by the lateral movement of organisms and by settlement of planktonic (larval) forms (Ely and Viani 2010). Recovery is expected to be quickest in areas of high productivity and turnover rates, high dispersal ability, planktonic larvae, and most importantly a source of benthic invertebrate recovery (downstream drift, aerial dispersal, etc.). In a study of the recovery rates of macroinvertebrate communities following disturbance, Niemi et al. (1990) found that 90% of the areas recovered within 1 year. In addition, NMFS (2005b) reports that macroinvertebrate community abundance and diversity recover rapidly after dredging river habitat, typically within a few weeks.

While the initial colonizers are often opportunistic species that differ from those that were present prior to sediment removal, over time, the new biotic community often comes to resemble the community prior to removal (Cohen 2008). However, because benthic areas are rapidly recolonized by macroinvertebrates following disturbance, and subjected to increased foraging by fish, it is possible that frequent disturbance from maintenance dredging could help nonnative invasive species spread and colonize disturbed benthic habitats (Hanson Environmental 2004). The potential spread of nonnative invasive species will be monitored and controlled by *CM13 Invasive Aquatic Vegetation Control*.

Overall, the effects of periodic and localized dredging on prey organisms are not expected to be significant. The area of suitable habitat for those species affected by dredging is a fraction of the total habitat area available in the Delta. Therefore short-term effects on prey availability for covered species are expected to be negligible.

Placement of riprap at levee breach locations or other areas where restoration or other conservation measures are constructed will result in temporary adverse effects on habitat, but will maintain the degraded habitat baseline over time (i.e., maintenance riprap will be used only to replace existing riprap that has failed). The magnitude of this effect will depend on site-specific conditions prior to placement of riprap. The associated habitat disturbance likely could result in localized effects on habitat suitability, including a reduction in benthic habitat condition and macroinvertebrate diversity and abundance.

5.H.7.4 Physical Injury or Loss of Individuals

Injury and loss of individual fish could occur during maintenance activities that use in-water equipment such as boats, barges and dredging equipment.

Injury or loss of fish is most likely to occur during dredging activities around the new intakes. Suction dredging, mechanical excavation, and possible front end–loading equipment can capture or crush fish, causing injury or mortality. Some special-status fish species, such as green sturgeon, are more likely to become entrained in the dredging equipment because they are benthic-oriented species. Salmonids and other fish that use main channel areas and the upper water column are therefore less likely to become injured or killed by dredging equipment. Dredging will be required infrequently, include relatively small areas of the river, typically occur during the approved in-water work window (June through October), and follow established BMPs typically used for maintenance dredging operation elsewhere in the Delta, such as the deepwater shipping channel dredging in the Sacramento and San Joaquin Rivers. Such BMPs could include minimizing the dredge flow field. Boysen and Hoover (2009) report that the probability of entraining white sturgeon can be minimized by reducing the dredge head flow field to less that 45 centimeters per second. This approach assumes that risk of entrainment is determined principally by dredge-induced water velocities and the swimming responses and abilities of sturgeon and other potentially vulnerable species. Total risk of entrainment, however, is a cumulative value associated with behavioral, physiological, and demographic data (Hoover et al. 2005). In addition to swimming performance data, a risk analysis will require information on responses of sturgeon to dredge-induced perturbations like noise and turbidity, and localized sturgeon abundance and distribution at the dredging location.

Entrainment rates for maintenance dredging of the Sacramento River navigation channels appear to have negligible effects for most covered species. For example, during 4 years of entrainment monitoring only two juvenile green sturgeon were observed in trawl studies, and these occurrences were outside of the proposed in-water work window (Mari-Gold Environmental Consulting and Novo Aquatic Sciences 2010). In 2008, the only covered species captured in the Sacramento River trawl surveys were 22 delta smelt, 21 longfin smelt, and 7 white sturgeon. These three species represented between 1.7% and 5.4% of the total catch of 405 fish (SWCA Environmental Consultants 2009). While no delta or longfin smelt were captured in similar sampling in 2009, 7 white sturgeon were captured (Mari-Gold Environmental Consulting and Novo Aquatic Sciences 2010).

While no lamprey were captured in the 2008 trawl surveys, a total of 31 were captured during dredge entrainment sampling, representing about 11% of the 278 fish captured (SWCA Environmental Consultants 2009). While about half of these lamprey were not identified to species those identified were all river lamprey. Similarly, only river lamprey were collected in sampling in 2007 and 2006, although one Pacific lamprey was collected in 2009 (SWCA Environmental Consultants 2007, 2008, 2009; Mari-Gold Environmental Consulting and Novo Aquatic Sciences 2010). Extrapolations based on the volume of the dredged material sampled in 2008 (468,272 cubic yards) predict that lamprey would have represented 33.6% of the total extrapolated entrainment estimate (6,483 fish). It is important to note that the area affected by navigation channel maintenance is considerably larger than the area that will be subject to construction and maintenance dredging (1,000+ acres versus approximately 23 acres); therefore, the probability of entrainment during construction and maintenance will be commensurately smaller.

Applying appropriate BMPs, as discussed in *CM22 Avoidance and Minimization Measures*, will minimize the potential effects of dredging and other periodic and localized maintenance activities on sturgeon and other covered fish species.

5.H.8 Conclusions

Table 5.H.8-1 summarizes conclusions about the potential effects on fish species and fish habitat of construction and maintenance activities associated with specific conservation measures. These conclusions are preliminary because the exact locations and timing of activities for most of these conservation measures have not yet been determined. The significance of potential effects on fish species will depend primarily on the presence of sensitive species and life stages relative to the timing of construction and maintenance activities.

Table 5.H.8-1. Construction and Maintenance Activities Associated with Conservation Measures and Potential Stressors and Effects on Fish and Fish Habitat

Construction and Maintenance Activities	CMs	Potential Stressors	Potential Effects on Fish/Fish Habitat	Effect Summary (accounts for species presence)
Impact pile driving	1	Underwater noise	Disturbance of fish passage, fish displacement, and/or fish injury or loss	Low to moderate adverse effect
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Toxins from sediments	Impairment of behavior, development, growth, and/or reproduction	No effect to low adverse effect
Vibratory sheet pile driving or vibratory pile driving	1, 16	Underwater noise	Disturbance of fish passage and/or fish displacement	Low adverse effect
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Toxins from sediments	Impairment of behavior, development, growth, and/or reproduction	No effect to low adverse effect
		Increased erosion/ sedimentation	Disturbance of rearing habitat	No effect to low adverse effect
		Disturbance of benthic habitat	Decreased foraging success	No effect to low adverse effect
Grading	2, 4, 5, 6, 7	Increased erosion/ sedimentation	Impairment of spawning and/or rearing	No effect to low adverse effect
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
Channel dredging/excavation	4, 5, 15	Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Resuspension of toxins attached to sediments	Impairment of behavior, development, growth, and/or reproduction	No effect to low adverse effect
		Disturbance/removal of channel sediments	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
			Disturbance, injury, and/or mortality of fish	

Construction and Maintenance Activities	CMs	Potential Stressors	Potential Effects on Fish/Fish Habitat	Effect Summary (accounts for species presence)
		Injury or loss of benthic invertebrates	Decreased forage for benthic feeding fish.	No effect to low adverse effect
Refueling, operating, and storing construction equipment and materials	1, 2, 4, 5, 6, 7, 14, 15, 16, 18, 19, 21	Accidental spills or runoff of toxins	Impairment of behavior, development, growth, and/or reproduction	No effect to low adverse effect
		Increased erosion/ sedimentation	Impairment of spawning, rearing, and/or migration habitat	No effect to low adverse effect
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
Placement/removal of rip-rap or other bank protection		Increased erosion/ sedimentation	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
Levee breaching	4, 5	Changes in channel morphology and hydraulics	Disturbance of fish passage and/or fish displacement	No effect to low adverse effect
			Impairment of spawning, rearing, and/or migration habitat	
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Increased erosion/ sedimentation	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
		Changes in flow velocities	Impairment of fish passage and/or fish displacement	No effect to low adverse effect
			Reduction in rearing habitat	
Construction of levees/embankments	4, 5	Removal/destruction of cover	Reduction in habitat quantity and/or quality	No effect to low adverse effect
		Changes in salinity	Disturbance of fish passage and/or fish displacement	No effect to low adverse effect
			Impairment of spawning, rearing, and/or migration habitat	

Construction and Maintenance Activities	**CMs**	**Potential Stressors**	**Potential Effects on Fish/Fish Habitat**	**Effect Summary (accounts for species presence)**
Use of equipment in riparian areas	1, 2, 4, 6, 7	Changes in noise, light from physical movements of people and equipment	Disturbance of fish passage and/or fish displacement	No effect to low adverse effect
Clearing, grubbing and/or demolition on riverbanks	1, 2, 4, 5, 6, 7, 14, 18, 19, 21	Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Increased erosion/ sedimentation	Disturbance of spawning and/or rearing areas	No effect to low adverse effect[1]
		Reduced cover/shade		
		Reduced input to river of leaves, insects	Reduced rearing habitat quality	No effect to low adverse effect[1]
Detour and levee reinforcement and setback levees	1	Bank disturbance	Reduced rearing habitat quality	No effect to low adverse effect[1]
Installation of aeration facilities	21	Changes in channel morphology and hydraulics	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
Removal of in-water docks, vessels, or barriers	1, 15, 16	Channel disturbance	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
		Disturbance of benthic habitat	Decreased foraging success	No effect to low adverse effect
Construction of dikes to maintain adjacent land uses	2, 4, 5	Increased erosion/ sedimentation	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
Installation of irrigation infrastructure and levees to control irrigation during vegetation establishment	2, 4	Increased erosion/ sedimentation	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
		Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	

Construction and Maintenance Activities	CMs	Potential Stressors	Potential Effects on Fish/Fish Habitat	Effect Summary (accounts for species presence)
Maintenance				
Use of in-water equipment; water control structure maintenance or replacement; infrastructure maintenance	1, 14, 16, 18, 19, 21	Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Toxins (from sediments and spills)	Impairment of behavior, development, growth, survival, and/or reproduction	No effect to low adverse effect
		Channel disturbance	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
		Increased erosion/ sedimentation	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect
Dredging	1,4, 16	Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Contaminant resuspension	Impairment of growth, and/or reproduction	No effect to low adverse effect
		Disturbance and/or removal of channel sediments	Impairment of spawning and/or rearing habitat	No effect to low adverse effect
			Disturbance, injury, and/or mortality of fish	No effect to low adverse effect
		Disturbance of benthic habitat	Decreased foraging success	No effect to low adverse effect
Levee maintenance (e.g., grading, breach repair, and riprap replacement)	2, 4, 5, 6, and 7	Increased turbidity	Altered foraging success	No effect to low adverse effect
			Altered predation risk	
			Reduced DO	
		Toxins (from sediments)	Impairment of growth and/or reproduction	No effect to low adverse effect
		Increased erosion/ sedimentation	Disturbance of spawning and/or rearing habitat	No effect to low adverse effect

DO = dissolved oxygen.

[1] Note that the level of effect will depend on location and extent that can be determined only when design and exact location of these features have been completed.

5.H.9 References Cited

5.H.9.1 Literature Cited

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