Table A-1. HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater and marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. <u>All expose life history stages:</u> Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u>: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u>: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u>: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	<u>Juveniles and adults</u>: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-1 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-2. HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

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Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater and marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u>: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	<u>Juveniles and adults</u>: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-2 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-3. HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

<table>
<tr><th rowspan="2">Sub-activity Type</th><th rowspan="2">Mechanism of Impact</th><th colspan="5">Exposure</th><th rowspan="2">Response to Stressor</th><th rowspan="2">Minimization Measures</th><th rowspan="2">Resulting Effects of the Submechanism</th></tr>
<tr><th>Stressor</th><th>When</th><th>Duration</th><th>Frequency</th><th>Life-history Form</th></tr>
<tr><td rowspan="9"></td><td colspan="9">Lacustrine</td></tr>
<tr><td>Altered wave energy</td><td rowspan="4">Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability
Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply</td><td>Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)</td><td>Permanent</td><td>Continuous</td><td rowspan="4">N/A</td><td rowspan="4">N/A</td><td rowspan="4">N/A</td><td rowspan="4">N/A</td></tr>
<tr><td>Altered current velocities</td><td>Year-round (with variable effects depending on site-specific current dynamics and project configuration)</td><td>Permanent</td><td>Intermittent</td></tr>
<tr><td>Altered nearshore circulation patterns</td><td>Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)</td><td>Permanent</td><td>Seasonal</td></tr>
<tr><td>Altered sediment supply</td><td>Year-round (beginning with project installation and becoming more pronounced over time)</td><td>Permanent</td><td>Continuous</td></tr>
<tr><td colspan="9">Ecosystem Fragmentation</td></tr>
<tr><td colspan="9">Marine and Riverine</td></tr>
<tr><td>Habitat loss and fragmentation</td><td>Change in habitat structure, availability, and suitability; reduced food web complexity</td><td>Year-round</td><td>Permanent</td><td>Continuous</td><td>Eggs and alevins;
Juveniles;
Adults</td><td><u>All exposed life-history stages</u>: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and riverine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.</td><td>Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.</td><td>May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.</td></tr>
</table>

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u>: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Riverine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and riverine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. <u>All expose life history stages:</u> Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and riverine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-3 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-4. HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	N/A	N/A	N/A	N/A
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Riverine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and riverine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Riverine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and riverine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and riverine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u>: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-4 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-5. HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Sockeye salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater and marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. <u>All expose life history stages:</u> Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u>: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u>: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u>: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Sockeye salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Decreased incubation success. <u>Juveniles and adults</u>: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. <u>Adults</u>: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-5 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-6. HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Steelhead salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater and marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles</u>: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Steelhead salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-6 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-7. HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Coastal Cutthroat salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater and marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Coastal Cutthroat salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-7 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-8. HPA HCP Channel Modifications Exposure and Response Matrix for -Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	<u>Eggs and alevins</u>: Decreased incubation success. <u>Adults</u>: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	N/A	N/A	N/A	N/A
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	N/A	N/A		N/A
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	N/A	N/A		N/A
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	N/A	N/A	N/A	N/A
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-8 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-9. HPA HCP Channel Modifications Exposure and Response Matrix for -Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins, as well as adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Bull Trout and Dolley Varden. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, nearshore circulation, and sediment supply are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u>: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. <u>All expose life history stages:</u> Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u>: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u>: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles</u>: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and alevins. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, alevins, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and alevins. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and alevins. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Bull Trout and Dolley Varden. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-9 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-10. HPA HCP Channel Modifications Exposure and Response Matrix for -Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and larvae. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and larvae; Adults	Eggs and larvae: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae, as well as adult spawning productivity.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>Eggs and larvae</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for freshwater migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if dredging places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and larvae. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs and larvae. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential scour and/or sedimentation of eggs and larvae, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg and larva life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and larvae. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and larvae. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success and larval survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs and larvae. May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and larvae. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and larvae; Adults	Eggs and larvae: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and larvae, as well as adult spawning productivity.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, larvae, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success and larval survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and larvae. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and larvae. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential scour and/or sedimentation of eggs and larvae, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larva life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs and larvae. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs and larvae. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during migration life-history phase.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Upstream migration is limited causing reduced and delayed migration, increased predation. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larva, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs and larvae, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-10 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and larvae. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-11. HPA HCP Channel Modifications Exposure and Response Matrix for -Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer in nearshore)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, increasing predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered streambank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and larvae; Adults	Eggs: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs, as well as adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered allochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	N/A	N/A	N/A	N/A
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	N/A	N/A		N/A
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	N/A	N/A		N/A
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile Olympic Mudminnow. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	N/A	N/A	N/A	N/A
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter freshwater littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. .
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, and increased predation exposure. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All exposed life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Egg; Juveniles; Adults	Eggs: Potential scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Increased stress, and decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during incubating egg life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Potential decreased egg incubation success survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. .	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Potential decreased egg incubation success survival due to water loss and stranding. Juveniles: Loss of habitat accessibility, stranding, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs: Changes in channel morphology and flow regime can alter substrate composition and stability, leading to decreased incubation success survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for Olympic Mudminnow. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival of incubating eggs. May affect survival and productivity at juvenile life-history stage..
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>Eggs:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, and increased predation exposure. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u>: behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing if channel incision presents a barrier to fish passage. Even when passage is provided, limitations on upstream migration may lead to decreased survival and spawning productivity due to increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered allochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and larvae; Adults	Eggs: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs, as well as adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high-intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high-intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and larvae; Juveniles	Eggs, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, larvae, and juveniles. Injury and stress may affect survival, growth, and fitness.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs: Changes in channel geometry, flow regime, wave energy, and nearshore circulation can lead to altered substrate composition. Alterations to substrate composition caused by these factors or directly through the placement of a sediment cap can lead to decreased incubation success survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May affect survival of incubating eggs. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Potential scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions (channels draining to lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Potential decreased egg incubation success survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. .	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Loss of habitat accessibility, stranding, reduced foraging opportunities, mortality and increased predation risk. Adults: Potentially reduced spawning productivity, foraging success, and increased mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs. May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for Olympic Mudminnows. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile life-history stage.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types if realignment places limitations on upstream migration that lead to decreased survival and spawning productivity due to increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>Eggs</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered allochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and survival, as well as adult spawning success and overall population productivity.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs: Decreased incubation success. Juveniles and adults: Decreased availability of thermal refuge habitat, limiting juvenile survival, growth, and fitness. May limit adult survival and spawning productivity. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	May affect survival of eggs, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, and increased predation exposure. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-11 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-12. HPA HCP Channel Modifications Exposure and Response Matrix for -Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness at all life-history stages
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: May reduce the availability of suitable refuge and foraging habitat, leading to reduced survival, growth, and fitness. Adults: Spawning is temperature dependent; alteration of nearshore temperature may affect spawning success and productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered streambank stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles; Adults	Juveniles and adults: Dace and suckers prey upon terrestrial insects recruited from riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth, fitness, and productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Alteration of habitat complexity may affect the suitability of spawning, rearing, and refuge habitat for dace and suckers, leading to reduced survival, growth, and fitness. Reduced habitat complexity may affect the availability of suitable spawning habitats for dace and sucker.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile and adult life-history stages. Reduced habitat complexity may affect spawning productivity.
	Altered groundwater–surface water interactions	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Juveniles	Juveniles: Dependence on groundwater–surface water exchange by these fish species is a data gap. However, lack of suitable thermal refuge habitat may lead to decreased survival during temperature extremes.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile dace, sucker and chub. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile and adult life-history stages. Decreased fitness may affect survival and productivity.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Eggs Juveniles; Adults	Eggs: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and juveniles: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	<u>All exposed life-history stages</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u>: Dredging can alter the wave energy reaching the shoreline and thereby alter lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg and juvenile life-history stages. May affect adult spawning productivity.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Adult dace spawning habitat availability may be limited by dredging, and by limitations on movement in the nearshore zone. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. Juveniles: Disconnection of floodplain habitats can lead to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness. Adults: Disconnection of sloughs and similar slow-water rearing habitats may limit the availability of suitable foraging and spawning habitat for dace. In moderate gradient habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, affecting survival, growth, fitness, and by extension, spawning productivity.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs; Juveniles; Adults	All exposed life-history stages: Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.

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Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	All exposed life-history stages: Acute low dissolved oxygen events may cause direct mortality of eggs, juveniles, and adults by asphyxiation. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs ; Juveniles; Adults	All exposed life history stages: Nutrient increases may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs ; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential substrate scour/or sedimentation, resulting in decreased incubation success. Juveniles and adults: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival, growth, and fitness during egg and juvenile life-history stages. May affect adult spawning growth and fitness.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs ; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs ; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs : Potential decreased egg incubation success and survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival of incubating eggs. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for juvenile dace, sucker and chub. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, and direct mortality. Dace and sucker dependency on groundwater is currently a data gap. However, decreased availability of thermal refuge may affect survival during temperature extremes.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival and productivity at juvenile and adult life-history stage. Decreased fitness may affect survival and productivity.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs; Juveniles; Adults	Eggs: High water temperatures may decrease egg survival. Juveniles: Reduced growth and fitness caused by temperatures outside optimal growth range, and alteration of food web patterns. Adults and juveniles: May reduce the availability of suitable refuge and foraging habitat, leading to reduced survival, growth, and fitness. Adults: Spawning is temperature dependent; alteration of nearshore temperature may affect spawning success and productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	All exposed life-history stages: Acute low dissolved oxygen events may cause direct mortality of eggs, juveniles, and adults by asphyxiation. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs. May affect juvenile survival, growth, and fitness.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Adult dace spawning habitat availability may be limited by gravel mining. Juveniles: Disconnection of floodplain habitats can lead to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness. Adults: Disconnection of sloughs and similar slow-water rearing habitats may limit the availability of suitable foraging and spawning habitat for dace. In moderate gradient habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, affecting survival, growth, fitness, and by extension, spawning productivity.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at all exposed life-history stages. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect survival, growth, and productivity of juvenile and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.		May affect juvenile and adult survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	Eggs: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: May reduce the availability of suitable refuge and foraging habitat, leading to reduced survival, growth, and fitness. Adults: Spawning is temperature dependent; alteration of nearshore temperature may affect spawning success and productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.
	Altered stream bank stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all exposed life history stages.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile and adult growth and survival.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs ; Juveniles; Adults	All exposed life-history stages: Dace and sucker dependency on groundwater is currently a data gap. However, decreased availability of thermal refuge may affect survival during temperature extremes.	Avoid disturbance of vegetation along stream.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat .. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, and juvenile life-history stages. May affect adult spawning productivity.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat if sediment capping places limitations on upstream migration that lead to decreased survival and spawning productivity due to delayed migration, increased exposure to predation and poaching, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane. • Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	<u>Eggs:</u> Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	<u>Eggs:</u> Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	<u>Eggs:</u> Mortality due to dewatering. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential substrate scour/or sedimentation, resulting in decreased incubation success. Juveniles and adults: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect egg incubation success; may affect juvenile and adult growth and fitness; .
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased egg incubation success due substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of incubating eggs. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of incubating eggs. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, and juvenile life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults	Juveniles: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for dace, sucker and chub. . This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival and productivity at juvenile and adult life-history stages.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions leading to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at juvenile and adult life-history stages. May affect adult spawn productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, and juvenile life-history stages. May affect adult spawning productivity.
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	<u>Eggs</u>: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. <u>Adults and juveniles</u>: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. <u>Adults</u>: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity. Dace and sucker dependency on groundwater is currently a data gap. However, decreased availability of thermal refuge may affect survival during temperature extremes.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, and juvenile life-history stages. May affect adult spawning productivity.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect survival, growth, and productivity of juvenile and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.		May affect survival, growth, and productivity of juvenile and adult life-history stages.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs; Juveniles; Adults	Eggs: High water temperatures may decrease egg survival. Juveniles: Reduced growth and fitness caused by temperatures outside optimal growth range, and alteration of food web patterns. Adults and juveniles: May reduce the availability of suitable refuge and foraging habitat, leading to reduced survival, growth, and fitness. Adults: Spawning is temperature dependent; alteration of nearshore temperature may affect spawning success and productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.
	Altered stream bank stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Dace feed on terrestrial insects. While less dependent, suckers are opportunistic feeders dependent on overall food web productivity. Reduced allochthonous inputs may affect food web productivity, leading to decreased foraging opportunities and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness at juvenile and adult life-history stages.

Table A-12 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased availability of suitable foraging and refuge habitat, leading to decreased foraging opportunities, increased competition, increased predation exposure, collectively affecting survival, growth, and fitness. Reduction in suitable spawning habitat area may affect spawning productivity.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	All exposed life-history stages: Dace and sucker dependency on groundwater is currently a data gap. However, decreased availability of thermal refuge may affect survival during temperature extremes.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs; Juveniles; Adults	All exposed life-history stages: Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64^{o}F for dace and 55–70^{o}F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	All exposed life-history stages: Acute low dissolved oxygen events may cause direct mortality of eggs, juveniles, and adults by asphyxiation. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-13. HPA HCP Channel Modifications Exposure and Response Matrix for -Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Transforming adults,	Transforming adults: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Transforming adults,	Transforming adults: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Transforming adults,	Transforming adults: Pause or change of migration direction; increased energy expense; reduced foraging success; increased predation exposure.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	May affect growth and survival; may delay outmigration, resulting in reduced marine survival.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Transforming adults,	Transforming adults: Attraction to lighted area, delaying or altering migration. Increased predation exposure.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival; may delay outmigration, resulting in reduced marine survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Transforming adults,	Transforming adults: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Direct mortality when exposed to temperatures over 68°F for continuous periods. Transforming adults: Altered growth and fitness when exposed to temperatures outside optimal growth range, and alteration of food web patterns, including food web supporting Pacific and river lamprey host fish. Adults and transforming adults: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation, rearing, and spawning.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered streambank stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	Eggs/ammocoetes: Decreased incubation success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey. Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Ammocoetes; Transforming adults	Transforming adults and ammocoetes: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of ammocoetes and transforming adults.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat for host fish of Pacific and river lamprey. Decreased suitable lamprey spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of transforming adults. May affect adult spawning success.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Transforming adults;	Transforming adults: See related stressor responses under Water Quality Alteration.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness of Pacific and river lamprey host fish. Adults: Decreased foraging opportunity due to decreased food web productivity, with resulting decreased growth and reproductive fitness of Pacific and river lamprey. River lamprey use nearshore habitats during this life-history phase, but dependence on habitat complexity remains a data gap.		May affect transforming adult survival and productivity. May affect adult growth and spawning productivity of Pacific and river lamprey host fish. Other effects on adult river lamprey are a data gap.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Eggs and ammocoetes; Transforming adults;	Eggs and ammocoetes; Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for host fish.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Eggs and ammocoetes	Eggs and ammocoetes: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased benthic DO levels.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	May affect egg and ammocoetes survival,

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when transforming adults occupy nearshore habitats for rearing)	Permanent	Continuous	Transforming adults; Adults (river lamprey)	Transforming adults and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for lamprey host fish, leading to decreased foraging opportunities for transforming adult Pacific and river lamprey, and adult river lamprey.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect growth and fitness at transforming adult life-history stages through effects on host fish. River lamprey are also known to use nearshore habitats during the adult life-history stage and will be subject to these effects during this period. Direct dependence on nearshore habitat characteristics for both species is a data gap. Decreased growth and fitness may affect survival and productivity during ocean migration life-history phase for both species. Western brook lamprey are non-anadromous and will not be exposed to these stressors.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when transforming adults occupy nearshore habitats for rearing)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	Ammocoetes: Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and affecting survival, growth, and fitness at this life-history stage. Transforming adults and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at ammocoete life-history stage. Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lamprey, and spawning productivity of adult lamprey.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Transforming adults	All exposed life-history stages: Dredging in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging river lamprey to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness. Pacific lamprey exposure to these stressors is minimal, as they primarily reside in offshore habitats during the transforming adult and adult life-history stages. Brook lamprey do not occur in the marine or lacustrine environments.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival and productivity at transforming adult life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. Dredging may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at egg, ammocoete, and transforming adult life-history stages. May affect spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Direct mortality due to winter ice formation and scour. Transforming adults: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and transforming adults: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during transforming adult development. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. Transforming adults and adults: A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and ammocoetes; Transforming adults; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Dredging may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth and fitness at all exposed life history stages.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments). Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential nest scour and/or sedimentation, resulting in decreased incubation success. Transforming adults: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, and decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and ammocoete life-history stages; may affect transforming adult growth and fitness; may affect adult spawning success.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential decreased egg incubation success and ammocoete survival due to turbidity exposure and substrate disturbance. Transforming adults and adults: For Pacific and river lamprey, decreased populations of host fish such as salmon could decrease available habitat.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of eggs and ammocoetes. May affect growth and fitness at transforming adult and adult life-history stages.
		Localized alteration in host fish abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults and adults: For Pacific and river lamprey, short-term reductions in host fish due to increased competition, decreased growth, and fitness are expected to affect growth and survival for these life-stages.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at transforming adult life-history stage.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	Transforming adults: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival, growth, and fitness at transforming adult life-history stage. May affect adult survival and spawning productivity.
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	Transforming adults and adults: Sediment supply and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for lamprey host fish, leading to decreased foraging opportunities for transforming adult Pacific and river lamprey, and adult river lamprey. Eggs and ammocoetes: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and transforming adults: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect egg and ammocoetes survival, may affect transforming adult survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg and ammocoete incubation)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Direct mortality when exposed to temperatures over 68°F for continuous periods. Transforming adults: Altered growth and fitness when exposed to temperatures outside optimal growth range, and alteration of food web patterns, including food web supporting Pacific and river lamprey host fish. Adults and transforming adults: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival, growth, and fitness during incubation, rearing, and spawning.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. Transforming adults and adults: A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Ammocoetes; Transforming adults	<u>All exposed life-history stages</u>: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. Depending on configuration, these structures may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, ammocoete, and transforming adult life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults	<u>Ammocoetes and transforming adults</u>: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect ammocoete and transforming adult growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Transforming adults; Adults	<u>Transforming adults and adults</u>: See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.		See effects for related stressors under Water Quality Modification.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Direct mortality due to winter ice formation and scour. Transforming adults: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and Transforming adults: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs and ammocoetes. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	Eggs/ammocoetes: Decreased incubation success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey. Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Ammocoetes; Transforming adults	Transforming adults and ammocoetes: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of ammocoetes and transforming adults.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat for host fish of Pacific and river lamprey. Decreased suitable lamprey spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect growth and fitness of transforming adults. May affect adult spawning success.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Transforming adults, Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	Eggs/ammocoetes: Decreased incubation success due to burial of eggs and rearing ammocoetes. Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Adults: Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Adhere to system-specific in-water work windows.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Transforming adults	<u>All exposed life-history stages</u>: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness. Pacific lamprey exposure to these stressors is minimal, as they primarily reside in offshore habitats during the transforming adult and adult life-history stages. Brook lamprey do not occur in the marine environment.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival and productivity at transforming adult life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u>: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. Depending on configuration, these structures may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at egg, ammocoete, and transforming adult life-history stages. May affect spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Ammocoetes; Transforming adults	Ammocoetes and transforming adults: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect ammocoete and transforming adult growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		Lamprey dependence on habitat complexity provided by aquatic vegetation is a data gap.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments). Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults present.	May affect survival and fitness at transforming adult life-history stage.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential nest scour and/or sedimentation, resulting in decreased incubation success. Transforming adults: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, and decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and ammocoete life-history stages; may affect transforming adult growth and fitness; may affect adult spawning success.
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	Transforming adults: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, and decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect transforming adult survival, growth, and fitness. May affect adult spawning fitness.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential decreased egg incubation success and ammocoete survival due to turbidity exposure and substrate disturbance. Transforming adults and adults: For Pacific and river lamprey, decreased populations of host fish such as salmon could decrease available habitat.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival of eggs and ammocoetes. May affect growth and fitness at transforming adult and adult life-history stages.
		Localized alteration in host fish abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults and adults: For Pacific and river lamprey, short-term reductions in host fish due to increased competition, decreased growth, and fitness are expected to affect growth and survival for these life-stages.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at transforming adult life-history stage.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	Transforming adults: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival, growth, and fitness at transforming adult life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments). Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Localized alteration in host fish abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults and adults: For Pacific and river lamprey, short-term reductions in host fish due to increased competition, decreased growth, and fitness are expected to affect growth and survival for these life-stages.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at transforming adult life-history stage.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>Eggs and ammocoetes</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. <u>Transforming adults</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Transforming adults; Adults (river lamprey)	Transforming adults and adults: Sediment supply and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for lamprey host fish, leading to decreased foraging opportunities for transforming adult Pacific and river lamprey, and adult river lamprey.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect growth and fitness at transforming adult life-history stages through effects on host fish. River lamprey are also known to use nearshore habitats during the adult life-history stage and will be subject to these effects during this period. Direct dependence on nearshore habitat characteristics for both species is a data gap. Decreased growth and fitness may affect survival and productivity during ocean migration life-history phase for both species. Western brook lamprey are non-anadromous and will not be exposed to these stressors.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. Depending on configuration, these structures may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, ammocoete, and transforming adult life-history stages. May affect spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u>: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. Depending on configuration, these structures may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, ammocoete, and transforming adult life-history stages. May affect spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Transforming adults; Adults	Transforming adults and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; Adults	Transforming adults and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness of Pacific and river lamprey host fish. Adults: Decreased foraging opportunity due to decreased food web productivity, with resulting decreased growth and reproductive fitness of Pacific and river lamprey. River lamprey use nearshore habitats during this life-history phase, but dependence on habitat complexity remains a data gap.		May affect transforming adult survival and productivity. May affect adult growth and spawning productivity of Pacific and river lamprey host fish. Other effects on adult river lamprey are a data gap.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Direct mortality when exposed to temperatures over 68°F for continuous periods. Transforming adults: Altered growth and fitness when exposed to temperatures outside optimal growth range, and alteration of food web patterns, including food web supporting Pacific and river lamprey host fish. Adults and transforming adults: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation, rearing, and spawning.
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	Eggs/ammocoetes: Decreased incubation success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey. Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Ammocoetes; Transforming adults	Transforming adults and ammocoetes: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of ammocoetes and transforming adults.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat for host fish of Pacific and river lamprey. Decreased suitable lamprey spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect growth and fitness of transforming adults. May affect adult spawning success.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	<u>Eggs and ammocoetes:</u> Direct mortality due to winter ice formation and scour. <u>Transforming adults</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and transforming adults</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during transforming adult development. May affect adult survival and spawning productivity.

Table A-13 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. Transforming adults and adults: A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.

Table A-14. HPA HCP Channel Modifications Exposure and Response Matrix for -Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Adults	Adults: See responses described under Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Adults	Adults: Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles; Adults	All exposed life-history stages: Sensitivity of these species to ambient light modification is currently a data gap.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	Effects of stressor exposure are unknown as species sensitivity to ambient light modification is a data gap.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles; Adults	All exposed life-history stages: Sensitivity of these species to ambient light modification is currently a data gap.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	Effects of stressor exposure are unknown as species sensitivity to ambient light modification is a data gap.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles; Adults	All exposed life-history stages: Sensitivity of these species to ambient light modification is currently a data gap.	Enforce speed and acceleration limits; avoid propeller cavitation.	Effects of stressor exposure are unknown as species sensitivity to ambient light modification is a data gap.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Sensitivity of sturgeon to auditory masking is currently a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Effects of stressor exposure are unknown as species sensitivity to auditory masking is a data gap.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of turnover time, stratification patterns, wind conditions, and other factors. However, the suitability of some protected habitats such as isolated embayments may be affected, leading to decreased rearing habitat availability and increased competition, leading to decreased growth and fitness. Adults: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness. Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.
	Altered streambank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles;	Eggs and larvae: Decreased incubation success and larval survival due to effects of turbidity exposure as described above under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation larval dispersal, as well as survival, growth, and fitness during juvenile rearing.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Juvenile sturgeon are opportunistic feeders and may utilize allochthonous inputs in the form of terrestrially insect-fall. Reduced foraging opportunities due to decreased food web productivity may lead to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Juveniles	Juveniles: Sturgeon dependence on groundwater exchange is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on groundwater-surface water exchange is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Adult sturgeon dependence on nearshore habitat complexity is limited. However, effects on habitat complexity may limit the availability and productivity of prey species; therefore, this stressor could indirectly affect adult growth and fitness. Given the extended marine foraging habitats used by sturgeon, localized effects are likely to be insignificant.		May affect juvenile survival, growth, and fitness.
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile survival, growth, and fitness.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in substrate composition can lead to decreased incubation success, and potentially increased predation exposure. Juveniles: Altered substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on Adults: Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime may cause larvae to be transported to environments unfavorable for survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and juveniles: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Adults	Adults: Wave energy, current velocity, sediment supply, substrate composition, and circulation patterns are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects may not be significant considering the wide ranging marine habitats of adult sturgeon.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect adult growth and fitness.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and circulation patterns are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juvenile rearing habitat. This may occur through increased predation exposure, food web alterations, and decreased foraging opportunity. Alteration of current and circulation patterns may prevent larvae transport to suitable rearing environments. The combined effect of these stressors can result in decreased survival, growth, and fitness at larval and juvenile life-history stages. Adults: Adult sturgeon are generally less sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at larval life-history stage. May affect growth and fitness at juvenile life-history stage. May affect adult growth and fitness, and adult spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness..	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness. Eggs and larvae: Decreased hyporheic exchange may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and juveniles: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles and larvae: Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: May affect settlement, leading to decreased larval survival. Juveniles and adults: Sturgeon feed opportunistically on benthic organisms, such as aquatic insect larvae and fish. Substrate effects on these prey organisms could affect prey availability, resulting in decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life-history stage. May affect juvenile and adult growth and fitness.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity. .

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime may cause larvae to be transported to environments unfavorable for survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and juveniles: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival, growth, and fitness.
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dikes and levees can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.		May affect survival during incubation larval dispersal, as well as survival, growth, and fitness during juvenile rearing.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								.
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). Adults: Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation, rearing, and spawning.
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased benthic dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Decreased incubation success and larval survival due to effects of turbidity exposure as described above under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation larval dispersal, as well as survival, growth, and fitness during juvenile rearing.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Juvenile sturgeon are opportunistic feeders and may utilize allochthonous inputs in the form of terrestrially insect-fall. Reduced foraging opportunities due to decreased food web productivity may lead to decreased growth and fitness.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile growth and fitness.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid disturbance of vegetation along stream.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Egg mortality due to membrane rupture. ▪ Fatal injury or permanent auditory tissue damage caused by barotraumas limiting to larval, juvenile, and adult survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness Note that actual sound sensitivity of primitive fish species such as sturgeon is currently a data gap, so actual harm thresholds are unknown.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May cause direct mortality or injury at all life-history stages. May affect survival, growth, and fitness at larval and juvenile life-history stages. Actual effects are uncertain as the sensitivity of these species to noise related stressors is currently a data gap.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, larvae, and juveniles. Injury and stress may affect survival, growth, and fitness.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles Adults	<u>Eggs and larvae</u>: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime may cause larvae to be transported to environments unfavorable for survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for sturgeon species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dams can reduce flow and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness. Eggs and larvae: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and juveniles: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	Juveniles: Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.		May affect juvenile survival, growth, and fitness.
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Egg mortality due to membrane rupture. ▪ Fatal injury or permanent auditory tissue damage caused by barotraumas limiting to larval, juvenile, and adult survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness Note that actual sound sensitivity of primitive fish species such as sturgeon is currently a data gap, so actual harm thresholds are unknown.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May cause direct mortality or injury at all life-history stages. May affect survival, growth, and fitness at larval and juvenile life-history stages. Actual effects are uncertain as the sensitivity of these species to noise related stressors is currently a data gap.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of eggs and larvae. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles and larvae: Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: May affect settlement, leading to decreased larval survival. Juveniles and adults: Sturgeon feed opportunistically on benthic organisms, such as aquatic insect larvae and fish. Substrate effects on these prey organisms could affect prey availability, resulting in decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life-history stage. May affect juvenile and adult growth and fitness.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juvenile (over 1 ft length-[marine]) and adults: Because of the limited temporal and spatial extent of alteration to sturgeon marine habitat, project effects on marine circulation are a relatively inconsequential component. Therefore, the magnitude of project hydrologic modification is expected to be negligible. As such, this stressor is not expected to significantly affect the marine environment, and there will be no response to the stressor.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	Effects from exposure to this stressor are expected to be insignificant and discountable.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May effect growth and fitness at juvenile life-history stage, mortality at all life-history stages, adult spawning fitness and productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles and larvae: Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs and larvae;	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in flow regime may cause larvae to be transported to environments unfavorable for survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larvae life-history stages. May affect adult spawning productivity.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in substrate composition and stability can lead to decreased incubation success, and potentially increased predation exposure. Juveniles: Altered substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dams can reduce flow and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dams can reduce flow and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and juveniles: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.		May affect juvenile survival, growth, and fitness.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). Adults: Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation, rearing, and spawning.
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles;	Eggs and larvae: Decreased incubation success and larval survival due to effects of turbidity exposure as described above under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation larval dispersal, as well as survival, growth, and fitness during juvenile rearing.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Juvenile sturgeon are opportunistic feeders and may utilize allochthonous inputs in the form of terrestrially insect-fall. Reduced foraging opportunities due to decreased food web productivity may lead to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles	Juveniles: Sturgeon dependence on groundwater exchange is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on groundwater-surface water exchange is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.

Table A-14 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival, growth, and fitness.

Table A-15. HPA HCP Channel Modifications Exposure and Response Matrix for -Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Adults: Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in-water work windows. May affect these parameters if activities occur during spawning and incubation.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles; Adults	The potential for this stressor to affect smelt is currently a data gap.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	Potential effects resulting from this impact mechanism are unknown.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles; Adults	The potential for this stressor to affect smelt is currently a data gap.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	Potential effects resulting from this impact mechanism are unknown.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon sensitivity to these stressors is currently a data gap.	Enforce speed and acceleration limits; avoid propeller cavitation.	Sensitivity to these stressors is currently a data gap; therefore, the potential effects resulting from this impact mechanism are unknown.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or hearing threshold effects decrease ability to sense predators and/or prey, increasing risk of predation and decreasing foraging efficiency.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs and larvae. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Adults	Adults: Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect spawning productivity.
	Altered streambank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during egg incubation; may affect spawning fitness and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect larval growth and fitness.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Adults	Adults: Reduced habitat complexity may affect the availability of suitable spawning habitat leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect adult spawning productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Aquatic Vegetation Modification								
	Marine Littoral								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown. .	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal				
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles			
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival at egg and larval life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round	Permanent	Continuous			Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Adults: Alteration of nearshore habitat parameters may affect survival and foraging opportunities at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at the larval and juvenile life-history stages. Decreased fitness may affect survival and productivity during ocean migration life-history phase, and may affect spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and circulation patterns are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging opportunities for longfin smelt at larval and juvenile life-history stages, leading to decreased adult fitness and decreased spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect productivity at larval and juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juvenile; Adult	<u>All exposed life-history stages</u>: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. Eulachon and longfin smelt are known to use marine nearshore habitat types during juvenile and adult life-history stages, and are likely to occur as larvae as well. May alter migration of adults toward spawning habitats, larval dispersal, and juvenile foraging, affecting survival, growth, and fitness at all life-history stages. Longfin smelt dependence on nearshore habitats in Lake Washington is currently a data gap. Therefore the effects of this stressor are unknown.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Larvae; Adults	<u>All exposed life-history stages</u>: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect egg survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs ; Juveniles; Adults	Eggs : Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs; Juveniles; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. Adults: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential scour of spawning substrate and/or sedimentation, resulting in decreased incubation success. Potential larval dispersal to unfavorable habitats, decreasing larval survival and productivity. Adults: Decreased availability of suitable spawning sites; decreased spawning success.	Limit alteration of flow conditions to minimal area.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted during in-water work windows. If activities are permitted during in-water work windows, activity may affect adult spawning productivity and egg and larval survival.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Adults: Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in-water work windows. May affect these parameters if activities occur during spawning and incubation.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May effect growth and fitness at juvenile life-history stage, mortality at all life-history stages, adult spawning fitness and productivity.
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles</u>: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of rearing habitat for smelt and eulochon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect all exposed life-history stages. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs ; Juveniles; Adults	<u>Eggs</u> : Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid large sediment pulses during construction and gravel mining activities.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Larvae; Adults	All exposed life-history stages: Gravel mining can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Adults	Adults: Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during egg incubation; may affect spawning fitness and productivity.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon feed on forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect larval growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Reduced habitat complexity may affect the availability of suitable spawning habitat leading to decreased spawning productivity.	Encourage project designs that limit permanent alteration of habitat features.	May affect adult spawning productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Avoid disturbance of vegetation along stream.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<u>Eggs and larvae</u>: Noise of sufficient magnitude may cause direct mortality of eggs and larval smelt or permanent injury leading to decreased survival and fitness. <u>Adults and juveniles</u>: Stressor response, depending on noise magnitude and project-specific environmental conditions, may range from: • Fatal injury or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning, incubation, and larval dispersal. The potential for juvenile exposure is less well known. Except for the landlocked Lake Washington population of longfin smelt, juvenile habitat use by these species is poorly understood. Subadults are known to migrate to offshore areas on the continental shelf.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and larvae	Eggs and larvae: burial or coating of eggs may lead to direct mortality.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs And larvae.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine and Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juvenile; Adult	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. Eulachon and longfin smelt are known to use these marine habitat types during juvenile and adult life-history stages, and are likely to occur as larvae as well. May alter migration of adults toward spawning habitats, larval dispersal, and juvenile foraging, affecting survival, growth, and fitness at all life-history stages. Longfin smelt dependence on nearshore habitats in Lake Washington is currently a data gap. Therefore the effects of this stressor are unknown.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Larvae; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.		Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larval smelt or permanent injury leading to decreased survival and fitness. Adults and juveniles: Stressor response, depending on noise magnitude and project-specific environmental conditions, may range from: • Fatal injury or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning, incubation, and larval dispersal. The potential for juvenile exposure is less well known. Except for the landlocked Lake Washington population of longfin smelt, juvenile habitat use by these species is poorly understood. Subadults are known to migrate to offshore areas on the continental shelf.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. Adults: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential scour of spawning substrate and/or sedimentation, resulting in decreased incubation success. Potential larval dispersal to unfavorable habitats, decreasing larval survival and productivity. Adults: Decreased availability of suitable spawning sites; decreased spawning success.	Limit alteration of flow conditions to minimal area.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted during in-water work windows. If activities are permitted during in-water work windows, activity may affect adult spawning productivity and egg and larval survival.
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect survival, growth, and fitness at the larval and juvenile life-history stages.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Adults: Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in-water work windows. May affect these parameters if activities occur during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased egg incubation success and survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May effect growth and fitness at juvenile life-history stage, mortality at all life-history stages, adult spawning fitness and productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. Adults: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Unlikely to affect smelt at any life-history stage.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect spawning productivity.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival all exposed life-history stages. May affect adult spawning productivity.
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Sediment supply and substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Adults: Alteration of nearshore habitat parameters may affect survival and foraging opportunities at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect survival, growth, and fitness at the larval and juvenile life-history stages. Decreased fitness may affect survival and productivity during ocean migration life-history phase, and may affect spawning productivity.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	See effects for related stressors under Water Quality Modification.
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Larvae; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at egg, larval, and juvenile life-history stages. May affect adult spawning productivity.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Larvae; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat. Minimize severing upstream-downstream connectivity by installing fish passage.	May affect survival, growth, and fitness at egg, larval, and juvenile life-history stages. May affect adult spawning productivity.
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Reduced habitat complexity may affect the availability of suitable spawning habitat leading to decreased spawning productivity.		May affect adult spawning productivity.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Adults	Adults: Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect spawning productivity.
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during egg incubation; may affect spawning fitness and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon feed on forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect larval survival, growth, and fitness.

Table A-15 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Reduced habitat complexity may affect the availability of suitable spawning habitat leading to decreased spawning productivity.	Encourage project designs that limit permanent alteration of habitat features.	May affect adult spawning productivity.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Avoid disturbance of vegetation during construction. Preserve existing vegetation to the extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs; Juveniles; Adults	Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.

Table A-16. HPA HCP Channel Modifications Exposure and Response Matrix for -Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses described under Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: The potential for this stressor to affect smelt and sand lance is currently a data gap.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	Potential effects resulting from this impact mechanism are unknown.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles; Adults	Adults and juveniles: The potential for this stressor to affect smelt and sand lance is currently a data gap.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	Potential effects resulting from this impact mechanism are unknown.

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect juvenile growth and fitness.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles	Larvae and juveniles: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Sensitivity to these stressors is currently a data gap; the potential effects resulting from this impact mechanism are unknown.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Entrainment of smelt and sand lance during dredging is likely to cause mortality or injury, leading to decreased survival. See responses described for related stressors under Water Quality Modification.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival of larvae and adults if activities are conducted during in-water work windows. Likely to affect survival at any life-history stage if exposure occurs. See effects for related stressors under Water Quality Modification.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival, decreasing population productivity.
	Altered shoreline and bluff stability	Increased suspended solids; decreased nest dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs: Smothering of incubating eggs or alteration of substrate composition may decrease egg survival. Larvae and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. Adults: Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect growth and fitness at larval and juvenile life-history stages. May affect adult spawning fitness and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Leaf litter and other detritus may influence microclimate conditions in spawning substrates. Reduction in leaf litter may cause reduced incubation success. Larvae, juveniles, and adults: Dependence on autochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. Potential effects resulting from this impact mechanism on remaining life-history stages are unknown.

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; the potential effects resulting from this impact mechanism are unknown.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Groundwater inflow demonstrably affects substrate temperatures, creating favorable conditions for egg incubation. Larvae and juveniles: Dependence of larval and juvenile forage fish on surface water and groundwater exchange in nearshore habitats is currently a data gap; the potential for exposure to these stressors is unknown. Adults: Altered groundwater inflow may affect spawning habitat suitability, leading to decreased spawning success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival and adult spawning productivity. Potential effects resulting from this impact mechanism on larvae and juveniles are unknown.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). All life-history stages: Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. .	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal				
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous				

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Egg incubation success may be affected by alteration in wave energy patterns and groundwater inputs. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities for at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at the larval and juvenile life-history stages. May affect juvenile and adult growth and fitness. Decreased fitness may affect spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u>: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>Larvae</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u>: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Larvae; Juveniles; Adults	<u>Larvae</u>: Decreased survival; increased incidence of developmental abnormalities leading to decreased survival and fitness. <u>Juveniles and adults</u>: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Contaminant exposure may cause avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival and productivity across all life-history stages. Reduced growth and fitness may affect adult spawning productivity.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	<u>NA</u>	NA	This species does not occur in habitats suitable for gravel mining and scalping; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	<u>NA</u>	NA	
		Altered flow conditions	NA	NA	NA	NA	<u>NA</u>	NA	

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Streambed disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	
		Increased suspended solids	NA	NA	NA	NA	NA	NA	
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	
	Construction equipment operation	Altered ambient noise levels	NA	NA	NA	NA	NA	NA	
		Bank/shoreline/channel disturbance, resulting in increased sediments	NA	NA	NA	NA	NA	NA	
		Exposure to toxic chemicals from accidental spills	NA	NA	NA	NA	NA	NA	
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	This species does not occur in habitats suitable for gravel mining and scalping; therefore, there is no potential for exposure to hydraulic and geomorphic modification impact mechanisms and related stressors.
	Altered flow regime		NA	NA	NA				
			NA	NA	NA				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	NA	NA	NA	NA	NA	NA	
	Altered groundwater-surface water interaction		NA	NA	NA				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	NA	NA	NA	NA	NA	NANA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA	NA	NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased nest dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	NA	NA	NA	NA	NA	NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Larvae; Juveniles; Adults	Larvae: Noise of sufficient magnitude may cause direct mortality of larvae, or permanent injury leading to decreased survival and fitness. Eggs are unlikely to be exposed to pile driving noise due to position in intertidal environment. Adults and juveniles: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury or permanent auditory tissue damage limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival and productivity during larval, juvenile, and adult life-history stages.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and larvae;	Eggs larvae, and juveniles: Injury or mortality from burial.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, and larvae
	Hydraulic and Geomorphic Modification								
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Egg incubation success may be affected by alteration in wave energy patterns and groundwater inputs. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities for at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		May affect survival at the larval and juvenile life-history stages. May affect juvenile and adult growth and fitness. Decreased fitness may affect spawning productivity.
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous		All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larval, juvenile and adult life-history stages. May affect adult spawning productivity.

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles Adults	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). All life-history stages: Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal				See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous				May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae: Decreased survival; increased incidence of developmental abnormalities leading to decreased survival and fitness. Juveniles and adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Contaminant exposure may cause avoidance behavior and increased stress, leading to reduced growth and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival and productivity across all life-history stages. Reduced growth and fitness may affect adult spawning productivity.

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment								Larvae; Juveniles; Adults	
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	NA	NA	NA	Eggs; Larvae; Juveniles; Adults	• NA	NA	This species does not occur in habitats suitable for channel creation and alignment; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Altered ambient noise levels	NA	NA	NA	NA	NA	NA	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Bank, channel, shoreline disturbance	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	NA	NA	NA
		Altered flow conditions (riverine)	NA	NA	NA	NA	NA	NA	NA
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	NA	NA	NA	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	NA
	Channel dewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	This species does not occur in habitats suitable for channel creation and alignment; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
	Altered substrate composition and stability		NA	NA	NA				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	NA	NA	NA	NA	NA	NA	NA
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	NA	NA	NA	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA		NA

Table A-16 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased nest dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	NA	NA	NA	NA	NA	NA	NA
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen levels	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-17. HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	The potential for this stressor to affect herring is currently a data gap.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	Potential effects resulting from this impact mechanism are unknown.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Larvae; Juveniles; Adults	The potential for this stressor to affect herring is currently a data gap.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	Potential effects resulting from this impact mechanism are unknown.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	Potential effects resulting from this impact mechanism are unknown, except as they pertain to effects on submerged aquatic vegetation (decreased spawning habitat substrate).

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered shoreline and bluff stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. Adults: Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect productivity at larval and juvenile life-history stages. May affect adult spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles; Adults	Juveniles and adults: Dependence on autochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism on remaining life-history stages are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect larval, juvenile, and adult productivity. May affect adult spawning productivity.

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Eggs; Larvae; Adults	Eggs and larvae: Herring egg and larval development is demonstrably affected by surface water salinities beyond tolerance thresholds. Alteration of salinity characteristics may limit egg survival or cause larval abnormalities limiting to survival, growth, and fitness. Adults: The influence of surface water and groundwater exchange on spawning habitat suitability is currently a data gap. However, alteration of this habitat parameter that affect submerged aquatic vegetation may decrease availability and/or suitability of spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg and larval survival and productivity. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. Adults: Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect productivity at larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal				
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous				

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation community resulting from these mechanisms may reduce available spawning habitat, leading to reduced spawning productivity. Egg incubation success may be affected by alteration in wave energy patterns. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities at the juvenile life-history stage, over time leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect egg and larval survival and larval fitness. Decreased larval fitness may affect survival and productivity during juvenile and adult life-history phases in offshore and open ocean environments, and may affect spawning productivity. Loss or alteration of suitable spawning habitat may affect spawning
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Dredging can alter the wave energy reaching the shoreline and thereby alter marine and lacustrine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect adult spawning productivity.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Eggs	Eggs: The influence of altered temperature regime on herring incubation is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	Decreased spawning habitat area. May affect larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs; Larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	This species does not occur in habitats suitable for gravel mining and scalping; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	NA	NA	NA
		Altered current and circulation conditions	NA	NA	NA	NA	NA	NA	NA
		Bottom disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	NA
	Construction equipment operation	Altered ambient noise levels	NA	NA	NA	NA	NA	NA	NA
		Bank/shoreline/channel disturbance, resulting in increased sediments	NA	NA	NA	NA	NA	NA	NA
		Exposure to toxic chemicals from accidental spills	NA	NA	NA	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered bathymetry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered current velocities		NA	NA	NA				
			NA	NA	NA				

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater-surface water interaction		NA	NA	NA				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	NA	NA	NA	NA	NA	NANA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA	NA	NA

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	NA	NA	NA	NA	NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	NA	NA	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	NA	NA	NA	NA	NA	NA

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larvae, or permanent injury leading to decreased survival and fitness. Adults and juveniles: Stressor response, dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury or permanent auditory tissue damage limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival during egg, larval, juvenile, and adult life-history stages.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs, larvae, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation community resulting from these mechanisms may reduce available spawning habitat, leading to reduced spawning productivity. Egg incubation success may be affected by alteration in wave energy patterns. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities at the juvenile life-history stage, over time leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Sediment caps can alter the wave energy reaching the shoreline and thereby alter marine habitats. This stressor may limit the availability of adult spawning and juvenile rearing habitat for herring. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larval, and juvenile life-history stages. May affect adult spawning productivity.

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. Adults: Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect productivity at larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.		May affect productivity at larval, juvenile, and adult life-history stages.

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	NA	NA	NA	NA	• NA	NA	This species does not occur in habitats suitable for gravel mining and scalping; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Altered ambient noise levels	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Bank, channel, shoreline disturbance	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	NA	NA	NA
		Altered flow conditions	NA	NA	NA	NA	NA	NA	NA
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	NA	NA	NA	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	NA
	Channel dewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered substrate composition and stability		NA	NA	NA				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	NA	NA	NA	NA	NA	NA	NA
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA

Table A-17 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	NA	NA	NA	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA		NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	NA	NA	NA	NA	NA	NA	NA
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen levels	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-18. HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	All exposed life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Potential for direct injury or mortality, and disturbance and displacement from vessel grounding and anchoring leading to increased stress and decreased growth and fitness. Adults and juveniles: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described above for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	Potential juvenile mortality or injury from grounding and anchoring. Stress from disturbance and displacement leading to decreased growth and fitness. See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Lingcod sensitivity to ambient light modification is currently a data gap.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	Effects of action are unknown as lingcod sensitivity to this stressor is currently a data gap.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Potential for attraction to lighted area and increased predation exposure is a data gap for lingcod.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: Lingcod sensitivity to ambient light modification is currently a data gap. See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Lingcod dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juveniles are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian autochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Juveniles	Juveniles: Juvenile lingcod are known to selectively settle and rear in areas with reduced salinities; therefore, groundwater inflow may provide increased habitat suitability. Reduction in suitable habitat area may affect survival, growth, and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages. .
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival, growth, and fitness at larval and juvenile life-history stages. .
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles	Juveniles: Ambient temperature has a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. (Egg exposure may occur in rare circumstances if nests are located close to shore.) Juveniles and adults: Avoidance behavior or asphyxiation during acute events.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival. May cause temporary avoidance behavior, potentially leading to decreased growth and fitness.

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	This species does not occur in habitats suitable for gravel mining and scalping; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	NA	NA	NA
		Altered flow conditions	NA	NA	NA	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	NA

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	NA
	Construction equipment operation	Altered ambient noise levels	NA	NA	NA	NA	NA	NA	NA
		Bank/shoreline/channel disturbance, resulting in increased sediments	NA	NA	NA	NA	NA	NA	NA
		Exposure to toxic chemicals from accidental spills	NA	NA	NA	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered flow regime		NA	NA	NA				
			NA	NA	NA				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater-surface water interaction		NA	NA	NA				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	NA	NA	NA	NA	NA	NANA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA	NA	NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	NA	NA	NA	NA	NA	NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury or permanent auditory tissue damage limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Eggs; Juveniles	Eggs and, juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs and juveniles. Injury and stress may affect survival, growth, and fitness.

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.		May affect survival, growth, and fitness at larval and juvenile life-history stages. .
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival, growth, and fitness at larval and juvenile life-history stages. .
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	NA	NA	NA	NA	• NA	NA	This species does not occur in habitats suitable for channel creation and alignment; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Altered ambient noise levels	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Bank, channel, shoreline disturbance	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	NA	NA	NA
		Altered flow conditions (riverine)	NA	NA	NA	NA	NA	NA	NA
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	NA	NA	NA	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	NA
	Channel dewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA NA	NA	NA	NA
	Altered substrate composition and stability		NA	NA	NA				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	NA	NA	NA	NA	NA	NA	NA
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation		NA	NA	NA	NA	NA	NA	NA
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	NA	NA	NA	NA	NA	NANA NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA		NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	NA	NA	NA	NA	NA	NA	NA
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	NA	NA	NA	NA	NA	NA	NA

Table A-18 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen levels	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-19. HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	All exposed life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Potential for direct injury or mortality, disturbance and displacement from vessel grounding and anchoring leading to increased stress, and decreased growth and fitness. Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	Potential juvenile mortality or injury from grounding and anchoring. Stress from disturbance and displacement leading to decreased growth and fitness. See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Juvenile pollock, cod, and hake sensitivity to ambient light modification is currently a data gap.	Design dredging plan so majority of temporary moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under moored vessels to limit changes in ambient light conditions.	Effects of action are unknown as receptor sensitivity to this stressor is currently a data gap.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Potential for attraction to lighted area and increased predation exposure is a data gap for Pacific cod, hake, and walleye pollock.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	Effects of action are unknown as receptor sensitivity to this stressor is currently a data gap.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: Direct sensitivity to ambient light modification is currently a data gap. See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid propeller cavitation.	Effects of action are unknown as receptor sensitivity to this stressor is currently a data gap. See effects for related stressors under Aquatic Vegetation Modification.

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	<u>Eggs and juveniles</u>: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of incubating eggs. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
	Riparian and Shoreline Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u>: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	<u>Juveniles</u>: Pacific cod, hake and walleye pollock dependence on autochthonous inputs from marine riparian vegetation is a data gap. However, juvenile Pacific cod, hake, and walleye pollock are known to use shallow vegetated habitats that could have marine riparian autochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered freshwater input	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Juveniles	<u>Juveniles</u>: Pacific cod, hake, and walleye pollock dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of action are unknown as receptor sensitivity to this stressor is currently a data gap.

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.		May affect juvenile growth and fitness

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	<u>Larvae and juveniles</u>: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval settlement in nearshore areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval settlement in nearshore areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles	Juveniles: Ambient temperature has a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Eggs; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	This species does not occur in habitats suitable for gravel mining and scalping; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	NA	NA	NA
		Altered flow conditions	NA	NA	NA	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	NA

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction equipment operation	Altered ambient noise levels	NA	NA	NA	NA	NA	NA	NA
		Bank/shoreline/channel disturbance, resulting in increased sediments	NA	NA	NA	NA	NA	NA	NA
		Exposure to toxic chemicals from accidental spills	NA	NA	NA	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA NA	NA	NA	NA
	Altered flow regime		NA	NA	NA				
			NA	NA	NA				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater-surface water interaction		NA	NA	NA				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	NA	NA	NA	NA	NA	NANA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA	NA	NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	NA	NA	NA	NA	NA	NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Barotraumas causing fatal injury or permanent auditory tissue damage in larvae, juveniles, and adults limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness and at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Egg; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to incubating eggs and juveniles. Injury and stress may affect survival, growth, and fitness.

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with variable effects by season)	Permanent	Seasonal	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval settlement in nearshore areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.		May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval settlement in nearshore areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.		May affect juvenile survival, growth, and fitness.

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	NA	NA	NA	NA	NA	NA	This species does not occur in habitats suitable for channel creation and alignment; therefore, there is no potential for exposure to construction-related impact mechanisms and related stressors.
		Altered ambient noise levels	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Bank, channel, shoreline disturbance	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA
		Entrainment in pumps or impingement on pump screens	NA	NA	NA	NA	NA	NA	NA
		Altered flow conditions (riverine)	NA	NA	NA	NA	NA	NA	NA

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	NA	NA	NA	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	NA	NA	NA	NA	NA	NA	NA
	Channel dewatering	Fish removal, relocation, and exclusion	NA	NA	NA	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered substrate composition and stability		NA	NA	NA				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	NA	NA	NA	NA	NA	NA	NA
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	NA	NA	NA	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	NA	NA	NA	NA	NA		NA
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	NA	NA	NA	NA	NA		NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	NA	NA	NA	NA	NA	NA	NA
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA

Table A-19 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	NA	NA	NA	NA	NA	NA	NA
	Altered dissolved oxygen levels	Decreased dissolved oxygen	NA	NA	NA	NA	NA	NA	NA

Table A-20. HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Potential for direct injury or mortality; disturbance and displacement from vessel grounding and anchoring leading to increased stress, as well as decreased growth and fitness. Adults and juveniles: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Site facilities in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	Potential juvenile mortality or injury from grounding and anchoring. Stress from disturbance and displacement leading to decreased growth and fitness. See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	NA	NA	NA	NA

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Rockfish sensitivity to ambient light modification is currently a data gap.	Design facilities so majority of structural and moorage shading occurs offshore away from submerged aquatic vegetation, movement corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under dock structure to limit changes in ambient light conditions.	Effects of action are unknown as rockfish sensitivity to this stressor is currently a data gap.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	Juveniles: Attraction to lighted area, delaying or altering movement. Increased predation exposure is a data gap for rockfish.	Reduce and shield facility and vessel lighting to limit nighttime illumination of the underwater environment.	May affect juvenile survival.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Juveniles	Juveniles: Rockfish sensitivity to ambient light modification is currently a data gap. See impact mechanisms, stressors, and stressor responses under Aquatic Vegetation Modification.	Enforce speed and acceleration limits; avoid cavitation.	Direct effects uncertain as sensitivity to stressor exposure is a data gap. See effects for related stressors under Aquatic Vegetation Modification.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. However, rockfish sensitivity to this stressor is currently a data gap.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect juvenile and adult survival due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is a data gap.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Direct mortality or injury from entrainment. Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. Adults : See responses described for related stressors under Water Quality Modification.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Rockfish dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile rockfish are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Juveniles	Juveniles: Rockfish dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting from this impact mechanism are unknown.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles	Juveniles: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. Adults: Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Dredging operations may fragment nearshore habitat, potentially affecting settlement of larval rockfish. May also affect nearshore habitat suitability for juvenile rockfish, however the resulting potential effects on rockfish populations are a data gap. Adults: The resulting potential effects on rockfish populations are a data gap.	Require minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult rockfish are a data gap.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u>: Ambient temperature has a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Larvae; Juveniles	<u>Larvae and juveniles</u>: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. <u>Juveniles</u>: Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May affect larval survival. May affect juvenile survival. May cause temporary avoidance behavior.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	<u>Larvae</u>: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. <u>Juveniles</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Larvae; Juveniles	<u>Larvae</u>: Decreased survival; increased incidence of developmental abnormalities leading to decreased survival and fitness. <u>Juveniles</u>: Avoidance, mortality, increased stress, reduced growth and fitness, tissue bioaccumulation, increased disease incidence, reduced additional stressor toleration, habitat avoidance, altered or delayed movement behavior.	Identify and demarcate all areas with contaminated sediments, manage and avoid causes of sediment disturbance (e.g., define and maintain vessel speed limits in sensitive areas). Ensure procedures are in place to quickly contain and clean up spills of toxic substances. Encourage the use of non-toxic, biodegradable lubricants in construction vessels.	May reduce growth and fitness and affect survival at larvae and juvenile life-history stages.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	NA
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	NA	NA	NA	NA
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA	NA	NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	NA	NA	NA	NA

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	NA	NA		NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA	NA	NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	NA	NA	NA	NA

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	NA	NA	NA	NA
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury or permanent auditory tissue damage limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury affecting juvenile and adult survival, depending on project-specific noise intensity and receptor exposure.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. However, rockfish sensitivity to this stressor is currently a data gap.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect juvenile and adult survival due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is a data gap.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from burial.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury to larvae, and juveniles. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Sediment capping operations may fragment nearshore rearing habitat, potentially affecting settlement of larval rockfish. May also affect nearshore habitat suitability for juvenile rockfish, however the resulting potential effects on rockfish populations are a data gap. Adults: The resulting potential effects on rockfish populations are a data gap.	Require minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult rockfish are a data gap.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. Adults: Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae: Decreased survival; increased incidence of developmental abnormalities leading to decreased survival and fitness. Juveniles: Avoidance, mortality, increased stress, reduced growth and fitness, tissue bioaccumulation, increased disease incidence, reduced additional stressor toleration, habitat avoidance, altered or delayed movement behavior.	Identify and demarcate all areas with contaminated sediments, manage and avoid causes of sediment disturbance (e.g., define and maintain vessel speed limits in sensitive areas). Ensure procedures are in place to quickly contain and clean up spills of toxic substances. Encourage the use of non-toxic, biodegradable lubricants in construction vessels.	May reduce growth and fitness and affect survival at larvae and juvenile life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury or permanent auditory tissue damage limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury affecting juvenile and adult survival, depending on project-specific noise intensity and receptor exposure.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. However, rockfish sensitivity to this stressor is currently a data gap.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect juvenile and adult survival due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is a data gap.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Larval relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of larvae. May cause direct injury or mortality of juveniles and adults.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival of larvae. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential decreased larval survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses.	Adhere to system-specific in-water work windows.	May affect survival of larvae. May affect growth and fitness at juvenile and adult life-history stage.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Loss of habitat accessibility, stranding, reduced foraging opportunities, mortality and increased predation risk.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival and spawning productivity.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Larval relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival of larvae. May cause direct injury or mortality of juveniles and adults.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, and substrate composition are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered nearshore circulation patterns	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Channel creation may fragment nearshore rearing habitat, potentially affecting settlement of larval rockfish. May also affect nearshore habitat suitability for juvenile rockfish, however the resulting potential effects on rockfish populations are a data gap. Adults: The resulting potential effects on rockfish populations are a data gap.	Require minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult rockfish are a data gap.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. Adults: Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Juveniles: Rockfish dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile rockfish are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles	Juveniles: Rockfish dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles	Juveniles: Ambient temperature has a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.

Table A-20 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae and juveniles: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May affect larval survival. May affect juvenile survival. May cause temporary avoidance behavior.

Table A-21. HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Potential and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating veliger larvae and juveniles. May affect juvenile productivity and adult productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults;	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults;	Juveniles: See responses described under Aquatic Vegetation Modification.	Site facilities in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults;	All life-history stages: Behavioral effect of ambient light changes is a data gap for the Olympia oyster.	Encourage moorage shading to occur offshore away from submerged aquatic vegetation and habitat.	Behavioral effect of ambient light changes is a data gap for the Olympia oyster.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Veliger larvae; Juveniles; Adults;	All life-history stages: Behavioral effect of ambient light changes is a data gap for the Olympia oyster.	Reduce and shield vessel lighting to limit nighttime illumination of the underwater environment.	Behavioral effect of ambient light changes is a data gap for the Olympia oyster.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Veliger larvae; Juveniles; Adults;:	All life-history stages: Behavioral effect of ambient light changes is a data gap for the Olympia oyster.	Enforce speed and acceleration limits; avoid cavitation.	Behavioral effect of ambient light changes is a data gap for the Olympia oyster.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults;	All life-history stages: Mortality from entrainment. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect veliger larvae productivity and fitness. See effects for related stressors under Water Quality Modification.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Juveniles and adults: Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
	Altered shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother Olympia oysters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described in Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles; Adults	Juveniles and adults: Olympia oyster dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased food resources, leading to adverse effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, adult spawning success, and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Veliger larvae; Juveniles: Adults	All life history stages: Olympia oyster are known to prefer areas where freshwater seepage into the intertidal zone likely limits extremes in temperature.	Avoid disturbance of riparian vegetation.	Effects from this impact mechanism may also include protection from predators unable to tolerate low salinity habitats.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project footprint to minimize disturbance of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile and adult growth, fitness, and survival.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Veliger larvae; Juveniles; Adults	All life-history stages: Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.		May affect survival of larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and productivity.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may also affect spawn timing and the transport and settlement of veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All exposed life-history stages: The footprint of dredging disturbance may limit the area suitable for larval settlement, decreasing overall juvenile and adult abundance.	Require minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult population abundance.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u>: Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u>: Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.	Avoid sediment pulses. Limit nutrient inputs associated with discharges of wastewater and gray water. Other mechanism-specific measures as appropriate.	May affect survival of incubating larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of larvae and juveniles. May affect juvenile productivity and adult productivity.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Veliger larvae; Juveniles; Adults	<u>Veliger larvae</u>: Decreased survival; increased incidence of developmental abnormalities, leading to decreased survival and fitness. <u>Juveniles and adults</u>: Mortality, increased stress, reduced growth and fitness, tissue bioaccumulation, increased disease incidence, and reduced additional stressor toleration.	Identify and demarcate all areas with contaminated sediments, manage and avoid causes of sediment disturbance. Ensure procedures are in place to quickly contain and clean up spills of toxic substances. Encourage the use of non-toxic, biodegradable lubricants in construction vessels.	May affect survival, growth, and fitness at egg, larvae, and juvenile life-history stages. Reduced growth and fitness may affect adult spawning productivity.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	<u>NA</u>	NA	NA
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	<u>NA</u>	NA	NA

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	NA
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	NA	NA	NA	NA
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA	NA	NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	NA	NA	NA	NA

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	NA	NA		NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	NA	NA	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA	NA	NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	NA	NA	NA	NA
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Juveniles, Adults	Juveniles and adults: Injury or mortality from entrainment or impingement.	Adhere to system-specific in-water work windows.	May cause direct mortality or injury to juveniles and adults. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered current velocities	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Veliger larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may also affect spawn timing and the transport and settlement of veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Veliger larvae; Juveniles; Adults
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All exposed life-history stages: The footprint of dredging disturbance may limit the area suitable for larval settlement, decreasing overall juvenile and adult abundance.	Require minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult population abundance.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project footprint to minimize disturbance of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile and adult growth, fitness, and survival.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Veliger larvae; Juveniles; Adults	All life-history stages: Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.		May affect survival of larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and spawning productivity.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of larvae and juveniles. May affect juvenile productivity and adult productivity.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Veliger larvae; Juveniles; Adults	Veliger larvae: Decreased survival; increased incidence of developmental abnormalities, leading to decreased survival and fitness. Juveniles and adults: Mortality, increased stress, reduced growth and fitness, tissue bioaccumulation, increased disease incidence, and reduced additional stressor toleration.	Identify and demarcate all areas with contaminated sediments, manage and avoid causes of sediment disturbance. Ensure procedures are in place to quickly contain and clean up spills of toxic substances. Encourage the use of non-toxic, biodegradable lubricants in construction vessels.	May affect survival, growth, and fitness at egg, larvae, and juvenile life-history stages. Reduced growth and fitness may affect adult spawning productivity.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased underwater noise level on Olympia oyster is a data gap.	Effect of increased underwater noise level on Olympia oyster is a data gap.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Potential and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Potential and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	Larvae: capture and relocation is impractical, likely leading to mortality Juveniles and adults: Mortality, injury, or stress from capture, handling, and relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of larvae, juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All life-history stages: Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. Mortality due to entrainment	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows.	May cause larval mortality due to entrainment. May affect juvenile and adult growth, fitness, and survival.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Potential and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Potential and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Loss of habitat accessibility, stranding, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival, growth, and fitness at juvenile and adult life-history stages.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	Larvae: capture and relocation is impractical, likely leading to mortality Juveniles and adults: Mortality, injury, or stress from capture, handling, and relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of larvae, juveniles and adults. Stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All exposed life-history stages: The footprint of dredging disturbance may limit the area suitable for larval settlement, decreasing overall juvenile and adult abundance.	Require minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult population abundance.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project footprint to minimize disturbance of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile and adult growth, fitness, and survival.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Veliger larvae; Juveniles; Adults	All life-history stages: Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.		May affect survival of larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Juveniles and adults: Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
	Altered shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother Olympia oysters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described in Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Olympia oyster dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.

Table A-21 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased food resources, leading to adverse effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, adult spawning success, and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Veliger larvae; Juveniles: Adults	All life history stages: Olympia oyster are known to prefer areas where freshwater seepage into the intertidal zone likely limits extremes in temperature.	Avoid disturbance of riparian vegetation.	Effects from this impact mechanism may also include protection from predators unable to tolerate low salinity habitats.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles; Adults	Juveniles and adults: Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of larvae and juveniles. May affect juvenile productivity and adult productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.	Avoid sediment pulses. Limit nutrient inputs associated with discharges of wastewater and gray water. Other mechanism-specific measures as appropriate.	May affect survival of incubating larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.

Table A-22. HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Loss of marine macroalgae may increase the visibility of the northern abalone to predators. See responses described under Riparian and Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Aquatic Vegetation Modification.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Larvae	Larvae: Behavioral effect of ambient light changes is a data gap for the northern abalone.	Encourage moorage shading to occur offshore away from submerged aquatic vegetation, movement corridors, and foraging habitats.	Behavioral effect of ambient light changes is a data gap for the northern abalone.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Larvae	Larvae: Behavioral effect of ambient light changes is a data gap for the northern abalone.	Reduce and shield facility and vessel lighting to limit nighttime illumination of the underwater environment.	Behavioral effect of ambient light changes is a data gap for the northern abalone.
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action				Larvae:	Larvae: Behavioral effect of ambient light changes is a data gap for the northern abalone.	Enforce speed and acceleration limits; avoid cavitation.	Behavioral effect of ambient light changes is a data gap for the northern abalone.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Effect of anthropogenic sound pressure on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. Mortality due to entrainment	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows.	May cause larval mortality due to entrainment. May affect juvenile and adult growth, fitness, and survival.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	NA	NA	NA	NA
	Altered shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother northern abalones if large pulses of landslide debris were to enter Puget Sound waters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	NA	NA	NA	NA

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input. Juveniles: Decreased habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Limit project footprint to minimize disturbance of aquatic vegetation to the greatest extent practicable.	Effect from autochthonous production is currently a data gap. May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Dredging operations may eliminate suitable habitat for larval settlement and juvenile and adult foraging.	Limit project footprint to minimize impacts. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival, growth, and fitness at all life-history stages.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	NA	NA	NA	NA
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of all life-history stages.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	NA
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	NA	NA	NA	NA
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	NA	NA	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA	NA	NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	NA	NA	NA	NA

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	NA	NA		NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	NA	NA	NA	NA
	Altered shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA	NA	NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	NA	NA	NA	NA

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	NA	NA	NA	NA
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Effect of anthropogenic sound pressure on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Effect of anthropogenic sound pressure on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Juveniles, Adults	Juveniles and adults: Decreased suitable habitat, injury, or mortality caused by burial.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May cause direct mortality or injury to juveniles and adults. Injury and stress may affect survival, growth, and fitness.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Sediment capping may eliminate suitable habitat for larval settlement and juvenile and adult foraging.	Limit project footprint to minimize impacts. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival, growth, and fitness at all life-history stages.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input. Juveniles: Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Limit project footprint to minimize disturbance of aquatic vegetation to the greatest extent practicable.	Effect from autochthonous production is currently a data gap. May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.
	Water Quality Modification								
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of all life-history stages.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All life-history stages</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. <u>All expose life history stages:</u> Sediment capping may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles and adults</u>: Effect of anthropogenic sound on northern abalone is a data gap.	Effect of anthropogenic sound on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles and adults</u>: Effect of anthropogenic sound on northern abalone is a data gap.	Effect of anthropogenic sound on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	<u>All life-history stages</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding. See responses to related stressors under Water Quality Modification.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages. See effects for related stressors under Water Quality Modification.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	<u>All life-history stages</u>: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: capture and relocation is impractical, likely leading to mortality Juveniles and adults: Mortality, injury, or stress from capture, handling, and relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of larvae, juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. Mortality due to entrainment	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows.	May cause larval mortality due to entrainment. May affect juvenile and adult growth, fitness, and survival.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Loss of habitat accessibility, stranding, reduced foraging opportunities, mortality and increased predation risk. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival, growth, and fitness at juvenile and adult life-history stages.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: capture and relocation is impractical, likely leading to mortality Juveniles and adults: Mortality, injury, or stress from capture, handling, and relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of larvae, juveniles and adults. Stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	NA

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Channel creation and alignment projects may eliminate suitable habitat for larval settlement and juvenile and adult foraging.	Limit project footprint to minimize impacts. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival, growth, and fitness at all life-history stages.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input. Juveniles: Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Limit project footprint to minimize disturbance of aquatic vegetation to the greatest extent practicable.	Effect from autochthonous production is currently a data gap. May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses for altered dissolved oxygen under Water Quality Modification.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	NA	NA	NA	NA
	Altered shoreline stability	Increased suspended solids; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother northern abalones if large pulses of landslide debris were to enter Puget Sound waters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	NA	NA	NA	NA
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Larvae; Juveniles; Adults	Larvae and juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult survival and spawning productivity.

Table A-22 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of all life-history stages.

Table A-23. HPA HCP Channel Modifications Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (*Salicornia Virginica*), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species. Disturbance to bed, banks, or shorelines in littorine snail habitat could lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.	Avoid/minimize disturbance of salt marsh habitat particularly the *Salicornia* fringe. Maintain system-appropriate buffer widths to the greatest extent possible. Encourage project designs that limit permanent alteration of high-quality habitat features.	Bed, bank or shoreline modification leading to the alteration of *Salicornia* habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	NA	Juveniles; Adults			
		Eelgrass and macroalgae disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for eelgrass and macroalgae recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (*Salicornia virginica*), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species, although its limited distribution and dependence on specific vegetation types increases sensitivity to specific types of riparian impacts. *Salicorna* fringe habitats are typically less influenced by riparian shade, but the actual shade requirements and life-history specific temperature requirements of this species are unknown. While tolerant of both salt and fresh water, it avoids immersion for long periods and will drown if trapped. Actual dependence on freshwater inflow is a data gap. However, salt marsh habitats in general are shaped by combined surface and ground water flows; therefore, alteration of freshwater inflow may lead to reduction in suitable habitat area.	Avoid/minimize disturbance of salt marsh vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Riparian vegetation modification leading to the alteration of *Salicorna* habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	NA	NA	NA	NA	NA	NA
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	NA	NA	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from dredging equipment operation.	NA	NA
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation							
		Decreased light penetration due to surface reflectance from fine bubble profusion produced by propeller action							
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	NA	NA				
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	NA	NA				
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (*Salicornia virginica*), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species, although its limited distribution and dependence on specific vegetation types increases sensitivity to specific types of riparian impacts. *Salicorna* fringe habitats are typically less influenced by riparian shade, but the actual shade requirements and life-history specific temperature requirements of this species are unknown. While tolerant of both salt and fresh water, it avoids immersion for long periods and will drown if trapped. Actual dependence on freshwater inflow is a data gap. However, salt marsh habitats in general are shaped by combined surface and ground water flows; therefore, alteration of freshwater inflow may lead to reduction in	Avoid/minimize disturbance of salt marsh vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Riparian vegetation modification leading to the alteration of *Salicorna* habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.
	Altered shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)				
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous				
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous				

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous		suitable habitat area.		
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	During dredging activities (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Seasonal	NA	NA		NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA		NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially altering the extent and composition of *Salicorna* habitat for Newcomb's littorine snail. In particular, alteration of littoral wave energy and sediment characteristics could lead to reductions in the amount of *Salicorna* habitat, or more frequent inundation leading to reduced habitat suitability. These alterations could lead to reduced survival, growth, and fitness; however, life-history specific sensitivity to these stressors is currently a data gap. As Newcomb's littorine snail is not a truly aquatic species and spends little time below the water surface, it is not affected by changes in current and circulation patterns.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all life-history stages. However, actual effects are uncertain as life-history specific sensitivity to these impact mechanisms and related stressors is currently a data gap.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent	NA			
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal	NA			
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults			
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time as caused by altered longshore drift patterns)	Permanent	Continuous	Juveniles; Adults			
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous	Juveniles; Adults			
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Dredging could alter marine littoral habitats where this species is found. This stressor may limit the availability of habitat affecting survival and overall population abundance.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Avoid/minimize disturbance of salt marsh vegetation.	May affect survival and overall population abundance.

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	NA	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (*Salicornia Virginica*), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species. While tolerant of both salt and fresh water, it avoids immersion for long periods and will drown if trapped and is therefore not exposed to these types of aquatic impacts from dredging operations.	NA	NA
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	NA		NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA		NA	NA
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	NA		NA	NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from gravel mining and scalping.	NA	NA
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA		NA	NA
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from gravel mining and scalping.	NA	NA
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	NA		NA	NA
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from gravel mining and scalping.	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA		NA	NA
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	NA		NA	NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from gravel mining and scalping.	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from gravel mining and scalping.	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	NA			NA
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA			NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from gravel mining and scalping.	NA	NA
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA		NA	NA
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	NA		NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA		NA	NA
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	NA		NA	NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from sediment capping.	NA	NA
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	NA		NA	NA
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	NA		NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from sediment capping.	NA	NA
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from sediment capping.	NA	NA
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from sediment capping.	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	NA			NA
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	NA			NA
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from sediment capping.	NA	NA
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	NA		NA	NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic noise impacts from channel creation and alignment. .	NA	NA
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA		NA	NA
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA		NA	NA
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Habitats used by this species are restricted to a narrow band littorine and riparian terrestrial vegetation and is therefore not exposed to aquatic impacts from channel creation and alignment.	NA	NA
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA		NA	NA
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially altering the extent and composition of *Salicorna* habitat for Newcomb's littorine snail. In particular, alteration of littoral wave energy and sediment characteristics could lead to reductions in the amount of *Salicorna* habitat, or more frequent inundation leading to reduced habitat suitability. These alterations could lead to reduced survival, growth, and fitness; however, life-history specific sensitivity to these stressors is currently a data gap. As Newcomb's littorine snail is not a truly aquatic species and spends little time below the water surface, it is not affected by changes in current and circulation patterns.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all life-history stages. However, actual effects are uncertain as life-history specific sensitivity to these impact mechanisms and related stressors is currently a data gap.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Channel creation and alignment may eliminate suitable habitat for this species, affecting survival and overall population abundance.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Avoid/minimize disturbance of salt marsh vegetation.	May affect survival and overall population abundance.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	NA	NA	NA
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous				

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (*Salicornia virginica*), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species, although its limited distribution and dependence on specific vegetation types increases sensitivity to specific types of riparian impacts. *Salicorna* fringe habitats are typically less influenced by riparian shade, but the actual shade requirements and life-history specific temperature requirements of this species are unknown. While tolerant of both salt and fresh water, it avoids immersion for long periods and will drown if trapped. Actual dependence on freshwater inflow is a data gap. However, salt marsh habitats in general are shaped by combined surface and ground water flows; therefore, alteration of freshwater inflow may lead to reduction in suitable habitat area.	Avoid/minimize disturbance of salt marsh vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Riparian vegetation modification leading to the alteration of *Salicorna* habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.
	Altered stream bank stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)				
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous				
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous				
	Altered groundwater–surface water interactions	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous				

Table A-23 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	NA	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (*Salicornia Virginica*), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species. While tolerant of both salt and fresh water, it avoids immersion for long periods and will drown if trapped and is therefore not exposed to these types of aquatic impacts from dredging operations.	NA	NA
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA		NA	NA
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	NA		NA	NA

Table A-24. HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Response to increased turbidity exposure as described for related stressors under Water Quality Modification. Response to benthic disturbance as described for Hydraulic and Geomorphic Modification.	Site facilities in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Water Quality Modification and Hydraulic and Geomorphic Modification.
		Eelgrass and macroalgae disturbance	NA	NA	NA	NA	NA	NA	NA
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: See responses described under Riparian and Aquatic Vegetation Modification.	Site facilities in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Juveniles	All life-history stages: The Columbia River limpet and spire snail light threshold and behavior respective to light changes are a data gap.	Design facilities so majority of structural and moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under dock structure to limit changes in ambient light conditions.	All life-history stages: The Columbia River limpet and spire snail light threshold and behavior respective to light changes are a data gap.
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Juveniles	All life-history stages: The Columbia River limpet and spire snail light threshold and behavior respective to light changes are a data gap.	Reduce and shield facility and vessel lighting to limit nighttime illumination of the underwater environment.	All life-history stages: The Columbia River limpet and spire snail light threshold and behavior respective to light changes are a data gap.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	All life-history stages: The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in dredge equipment is a data gap.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in dredge equipment is a data gap.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
	Altered streambank stability	Increased suspended solids; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Prefers high levels of dissolved oxygen and cool water. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Juveniles	Juveniles: Reduced prey resource availability due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult life-history stages.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased prey resource availability, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality and decreased fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	N/A	N/A	N/A	N/A	N/A	N/A	N/A.
	Aquatic Vegetation Modification								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness. Adults: Increased mortality and decreased fitness	Limit dredging footprint to avoid alteration of native vegetation community to the extent practicable	May affect juvenile and adult survival and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults	<u>All life-history stages:</u> Sediment supply and substrate composition are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply.	May affect all life-history stages; decreased growth, survival, and productivity.
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All life-history stages:</u> Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability, increased stress and predation rate, and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect all life-history stages; decreased growth, survival, and productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>All life-history stages:</u> Altered flow/exchange hyporheic can result in decreased habitat suitability, increased stress, and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	May affect all life-history stages; decreased growth, survival, and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of habitat. If dredging places limitations on upstream migration that lead to decreased survival and productivity due increased exposure to predation, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult and juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at all life-history stages.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Avoid sediment pulses. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity. Limit nutrient inputs associated with discharges of wastewater and gray water.	May affect productivity and survival of all life-history stages.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Mortality from dewatering.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Mortality and reduced survival and productivity at affected life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Potential downstream sedimentation resulting in decreased downstream habitat suitability; decreased dissolved oxygen levels, reduced prey resource availability, and reduced suitable settling habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival and productivity during all affected life-history stages.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows.	May affect growth and productivity at all life-history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased survival due to loss a food resources (small crustaceans attached to rocks and gravel).	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and productivity at all life-history stages.

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Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Effects of anthropogenic sound to giant Columbia River limpet and great Columbia River spire snail are a data gap.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	All life-history stages: Effects of anthropogenic sound to giant Columbia River limpet and great Columbia River spire snail are a data gap.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All life-history stages: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selections of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect all life-history stages; decreased growth, survival, and productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival and productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Avoid large sediment pulses during construction and gravel mining activities. Limit nutrient inputs associated with discharges of wastewater and gray water. Other mechanism-specific measures as appropriate.	May affect productivity and survival of all life-history stages.
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Gravel mining can lead to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of habitat. If dredging places limitations on upstream migration that lead to decreased survival and productivity due increased exposure to predation, and other related stressors. Decreased habitat availability may lead to density-dependent effects on adult and juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at all life-history stages.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile and adult productivity and survival.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Alteration.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness. Adults: Increased mortality and decreased fitness		May affect juvenile and adult survival and productivity.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
	Altered stream bank stability	Increased suspended solids; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced prey resource availability due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile and adult survival and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	NA	NA	NA	NA	NA
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles, Adults	All life-history stages: The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Juveniles, Adults	All life-history stages: The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.
	Burial	Loss of mobility and access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Juveniles, Adults	All life-history stages: Injury or mortality from burial. Responses vary depending on stressor magnitude. Could limit growth and survival.	Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All life-history stages: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, and substrate composition to the greatest extent practicable.	May affect growth, fitness , and survival at all life-history stages.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of habitat. Sediment capping places limitations on upstream migration that lead to decreased survival and productivity due to increased exposure to predation, and other related stressors. Decreased habitat availability may lead to density-dependent effects on juvenile and adult survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at all life-history stages.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile and adult productivity and survival.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Alteration.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness.		May affect juvenile and adult survival and productivity..

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. All expose life history stages: Sediment capping may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	All life-history stages: The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May decrease survival and productivity.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Mortality from dewatering.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Mortality and reduced survival and productivity at affected life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Potential downstream sedimentation resulting in decreased downstream habitat suitability; decreased dissolved oxygen levels, reduced prey resource availability, and reduced suitable settling habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival and productivity during all affected life-history stages.
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect growth and productivity at all life-history stages..
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows.	May affect growth and productivity at all life-history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased survival due to loss a food resources (small crustaceans attached to rocks and gravel).	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Barrier to migration, loss of habitat accessibility, stranding, reduced foraging opportunities, mortality and increased predation risk.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and productivity at all life-history stages.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Mortality from dewatering.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Mortality and reduced survival and productivity at affected life-history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased survival due to loss a food resources (small crustaceans attached to rocks and gravel).	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All life-history stages: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability, increased stress and predation rate, and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and sediment supply to the greatest extent practicable.	May affect survival and productivity at all life-history stage.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	All life-history stages: Altered flow/exchange hyporheic can result in decreased habitat suitability, increased stress, and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	May affect all life-history stages; decreased growth, survival, and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Altered longitudinal connectivity Altered river-floodplain connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of habitat. Realignment places limitations on upstream migration that lead to decreased survival and productivity due to increased exposure to predation, and other related stressors. Decreased habitat availability may lead to density-dependent effects on juvenile and survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize designs that sever upstream-downstream connectivity.	May affect survival at all life-history stages.
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	N/A	N/A	N/A	N/A	N/A	N/A	N/A.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile and adult growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Alteration.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness. Adults: Increased mortality and decreased fitness		May affect juvenile and adult survival and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
	Altered stream bank stability	Increased suspended solids; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced prey resource availability due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of habitat features.	May affect juvenile and adult survival and productivity.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA	NA
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect survival and productivity.

Table A-24 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Avoid large sediment pulses during construction. Revegetate riparian vegetation immediately.	May affect productivity and survival of all life-history stages.

Table A-25. HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dredging									
	Dredging Equipment Operation								
	Bank, channel, shoreline disturbance	Increased suspended solids	During dredging activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	One event or interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline, and benthic disturbance. Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity. Use proper erosion control BMPs.	May affect juvenile and adult survival.
	Bed disturbances from grounding, anchoring, and prop wash	Increased turbidity, disturbed benthic area	During dredging activities	Intermediate-term to long-term (dependent on time required for bed recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults;	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance.	May affect juvenile and adult survival.
		Freshwater aquatic vegetation disturbance	During dredging activities (effects most prevalent during spring and summer growth periods with intensity dependent on activity)	Intermediate-term to long-term (dependent on time required for aquatic vegetation recovery)	One event or interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: See responses described under Aquatic Vegetation Modification.	Anchor vessels in deeper water to avoid suspension of sediments from prop wash and grounding. Prevent or discourage anchoring, and provide alternatives such as mooring buoys designed in accordance with USACE guidance. Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
	Temporary ambient light modification	Daytime shading from moored vessel hulls, creating light contrasts and requiring visual and behavioral adaptation	During dredging activities (stressor exposure occurs in spring and summer during nearshore migration)	Temporary (during dredging)	Daily during construction or interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: Mussels are not visual feeders; therefore, this is not expected to be a direct stressor. However, this stressor may affect the dispersal of larvae through indirect effects on the health and fitness of host fish.	Design facilities so majority of structural and moorage shading occurs offshore away from submerged aquatic vegetation, migration corridors, and foraging habitats. Allow at least 10^{-4} ft-c light under dock structure to limit changes in ambient light conditions. Such measures could support host-fish.	Mussels are not visual feeders; therefore, this is not expected to be a stressor. May be an indirect effect by affecting the health and fitness of host fish.

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Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Nighttime artificial facility and vessel lighting, creating light contrasts requiring visual and behavioral adaptation				Glochidia larvae; Juveniles; Adults	All exposed life-history stages: Mussels are not visual feeders; therefore, this is not expected to be a stressor. However, this stressor may affect the dispersal of larvae through indirect effects on the health and fitness of host fish.	Reduce and shield facility and vessel lighting to limit nighttime illumination of the underwater environment.	Mussels are not visual feeders; therefore, this is not expected to be a stressor. May be an indirect effect by affecting the health and fitness of host fish.
	Noise-related disturbances	Altered ambient noise levels	During dredging activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of alteration of ambient noise on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	Very little is known of the effects of ambient noise on California floater and western ridged mussels at any life-history stage.
	Entrainment	Entrainment in dredge equipment (suction dredge or buckets)	During dredging activities	Temporary (during dredging)	Interannual to decadal (depending on activity frequency)	Glochidia larvae ;	Glochidia larvae: Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when glochidia fish host are present.	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity at all life history stages.
	Altered streambank stability	Increased suspended solids; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All life-history stages: Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels and host fish.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Glochidia larvae	Mussel dependence upon allochthonous input is a data gap. However, could affect host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat (freshwater)	Year-round	Short-term to long-term (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, and overall population productivity.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Short-term to long-term (dependent on nature of riparian impacts)	Continuous	Glochidia larvae; Juveniles; Adults	Mussel responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Effect of groundwater exchange to mussel health and fitness is a data gap.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decrease growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous could be expected to effect prey resource availability.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect all life stages.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability.	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.
	Altered channel geometry		Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults			
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: Altered flow/exchange hyporheic can result in decreased habitat suitability, increased stress, and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	May affect survival at juvenile and adult life-history stages.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult mussels. This may occur through increased predation exposure, food web alterations and decreased foraging opportunity. Effects to host fish affect these mussels.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. Juveniles and adults: The structural footprint of jetties may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. If dredging places limitations on upstream migration that lead to decreased survival and productivity. Decreased habitat availability may lead to density-dependent effects on survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Host-fish of the California floater and Western ridged mussel may be affected by increased temperatures, which may lead to mortality or increased thermal stress and decreased fitness of host fish. Juveniles and adults: Mortality due to increased temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect all life stages.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to continuous (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels. Juveniles and adults: A physiological response to exposure at toxic levels, causing mortality or injury leading to reduced fitness is a data gap.	Avoid sediment pulses. Limit nutrient inputs. Other mechanism specific measures as appropriate.	May affect survival of larvae. May affect juvenile survival and adult survival and productivity.
	Altered suspended sediments and turbidity	Increased suspended solids	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	During dredging activities	Temporary to short-term (dependent on contributing mechanism of impact)	Continuous	Glochidia larvae; Juveniles; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Dredging may lead to the introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Avoid dredging activities that resuspend toxic compounds or that limit nearshore circulation.	May affect survival, growth, and fitness at all exposed life-history stages.
Gravel Mining and Scalping									
	Construction and Maintenance Activities								
	Dewatering, flow bypass, fish handling, and channel rewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	River beds containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	May affect survival at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	Glochidia larvae: Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when glochidia fish host are present.	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival in all life stages.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows. Limit area of dewatering to the greatest extent practicable.	May affect survival at juvenile and adult life-history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	NA	NA	NA	NA	NA	NA

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. Juvenile and adults: Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival in all life stages.
	Construction equipment operation	Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of alteration of ambient noise on California floater and western ridged mussels is a data gap.	Little is known on the effects of anthropogenic sounds on California floater and western ridged mussels. Promote use of equipment equipped with antinoise/antivibration technology where practicable.	Very little is known of the effects of ambient noise on California floater and western ridged mussels at any life-history stage.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival. See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	May affect juvenile and adult survival. See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All exposed life history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth and fitness.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	May affect survival, growth, and fitness at all exposed life-history stages.
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
			Year round	Permanent	Continuous				

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles: Sediment supply and groundwater-surface water interactions are core ecosystem characteristics that compose riverine ecosystems. Alteration in these parameters can fundamentally alter riverine habitats, potentially decreasing the suitability of habitat for mussels. This may occur through a number of specific stressors, including increased exertion and stress due to food-web alterations and decreased foraging opportunity, and increased competition for suitable habitats. This may limit foraging opportunities leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Limit gravel extraction to below ambient supply rates for a limited period of time to allow channel recovery back to ambient levels. Encourage selection of project designs that minimize effects on sediment supply and groundwater-surface water interactions.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.
	Altered groundwater-surface water interaction		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Host fish of the California floater and Western ridged mussel may be affected by increased temperatures, which may lead to mortality or increased thermal stress and decreased fitness of host fish. Juveniles and adults: Mortality due to increased temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. Provide sufficient streamflows to avoid temperature effects in reaches downstream of gravel pits. Promote gravel mining operations that limit open pits within the channel migration zone.	May affect all life history stages.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host fish could be stressor to these mussels. Juveniles and adults: A physiological response to exposure at toxic levels, causing mortality or injury leading to reduced fitness is a data gap.	Avoid sediment pulses. Limit nutrient inputs. Other mechanism specific measures as appropriate.	May affect survival of larvae. May affect juvenile survival and adult survival and productivity.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Lateral and longitudinal habitat fragmentation	Fragmentation of side channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. All exposed life-history stages: Dredging can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. If dredging places limitations on upstream migration that lead to decreased survival and productivity. Decreased habitat availability may lead to density-dependent effects on survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Altered food-web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adult	All life-history stages: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect all life stages.
		Altered dissolved oxygen levels due to reduced photosynthesis			Seasonal	Juveniles; Adults	Juveniles and adults: Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration. Effects include effects to host fish.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decrease growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous could be expected to effect prey resource availability.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect all life stages.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect all life history stages.
	Altered stream bank stability	Increased suspended solids; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All life-history stages: Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels and host fish.
	Altered allochthonous input	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Glochidia larvae	Mussel dependence upon allochthonous input is a data gap. However, could affect host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous	Glochidia larvae; Juveniles; Adults	Mussel responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Effect of groundwater exchange to mussel health and fitness is a data gap.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Sediment Capping									
	Construction and Maintenance Activities								
	Materials placement	Elevated noise	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	All life-history stages: The effect of pile-driving sound pressure on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater = native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this species. This indirect effect applies to all stressors.
	Vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Temporary (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of alteration of ambient noise on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	Very little is known of the effects of ambient noise on California floater and western ridged mussels at any life-history stage.
	Burial	Loss of access to nutrients	During project construction and maintenance activities	Short-term	Temporary (during project construction and maintenance)	Juveniles, Adults	Decreased suitable habitat, injury, or mortality caused by burial.	Encourage project designs that limit permanent alteration of high-quality habitat features. River beds containing live freshwater mussels should not be disturbed. If live mussels are encountered.	May cause direct mortality or injury to juveniles and adults. Injury and stress may affect survival, growth, and fitness.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered wave energy		Year-round (with variable effects by season)	Permanent	Seasonal				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. Juveniles and adults: The structural footprint of jetties may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riverine								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. All exposed life-history stages: Sediment caps can alter flow patterns, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult habitat for species dependent on these habitat types. If sediment capping places limitations on upstream migration that lead to decreased survival and productivity. Decreased habitat availability may lead to density-dependent effects on survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize sediment capping and related activities that sever upstream-downstream connectivity.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.
	Altered river-floodplain connectivity		Year-round	Permanent	Continuous				
	Altered groundwater-surface water interactions		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	All life-history stages: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Avoid/minimize disturbance of aquatic vegetation during project construction.	All life-history stages: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration. Effects include effects to host fish.		See effects for related stressors of altered dissolved oxygen under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decrease growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous could be expected to effect prey resource availability.		May affect all life stages.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered nutrient and pollutant loading	Altered nutrient cycling and introduction of toxic substances	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	All exposed life history stages: Nutrient increase may result from decreased nutrient cycling from loss of riparian and aquatic vegetation, altered groundwater-surface water exchange, and altered temperatures. Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels. Sediment capping may lead to introductions of toxic substances through accidental spills or other pathways. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Encourage construction materials and techniques that do not introduce toxic substances.	May affect survival, growth, and fitness at all exposed life-history stages.
Channel Creation and Alignment									
	Construction and Maintenance Activities								
	Construction equipment operation	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	All life-history stages: The effect of pile-driving sound pressure on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this species. This indirect effect applies to all stressors.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of alteration of ambient noise on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	Very little is known of the effects of ambient noise on California floater and western ridged mussels at any life-history stage.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
	Bank, channel, shoreline disturbance	Increased suspended solids	During project construction and maintenance activities	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
	Temporary dewatering and flow bypass	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	River beds containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	May affect survival at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	Glochidia larvae: Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when glochidia fish host are present.	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival in all life stages.
		Altered current and circulation conditions (channels draining to marine and lacustrine environments)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect survival in all life stages.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect survival at juvenile and adult life-history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	NA	NA	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. Juveniles: Loss of habitat accessibility, stranding, increased predation risk. Stranding may lead to direct mortality. Adults: Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	May affect survival in all life stages.
	Channel dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	River beds containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	May affect survival at juvenile and adult life-history stages.
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
	Hydraulic and Geomorphic Modification								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.
	Altered substrate composition and stability		Year-round	Permanent	Continuous				
	Altered flow regime	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered sediment supply	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability as a result of beach erosion from altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: Altered sediment supply can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: Altered flow/exchange hyporheic can result in decreased habitat suitability, increased stress, and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on hyporheic flow/exchange to the greatest extent practicable.	May affect survival at juvenile and adult life-history stages.
	Ecosystem Fragmentation								
	Altered longitudinal connectivity	Fragmentation of side-channel and floodplain habitat; fragmentation of longitudinal (i.e., upstream-downstream) habitat connectivity; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. All exposed life-history stages: Channel realignment can alter the flow regime and force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. If channel realignment places limitations on upstream migration that lead to decreased survival and productivity. Decreased habitat availability may lead to density-dependent effects on survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat and effects on groundwater exchange. Minimize dredging that severs upstream-downstream connectivity.	May affect survival at all life-history stages and affect life-history stages and productivity of host fish.
	Altered river-floodplain connectivity	Fragmentation of side channel and floodplain habitat; fragmentation of upstream-downstream habitat; change in habitat structure, availability, and suitability.	Year-round	Permanent	Continuous				
	Altered groundwater-surface water exchange	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	Juveniles;	Mussel responses to altered groundwater-surface water exchange are a data gap.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effect of groundwater exchange to mussel health and fitness is a data gap.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Glochidia larvae; Juveniles; Adult	All life-history stages: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect all life stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration. Effects include effects to host fish.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decrease growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous could be expected to effect prey resource availability.		May affect all life stages.
	Riparian Vegetation Modification								
	Altered shading and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity at all life history stages.
	Altered stream bank stability	Increased suspended solids; decreased area of suitable habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All life-history stages: Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels and host fish.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Glochidia larvae	Mussel dependence upon allochthonous input is a data gap. However, could affect host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect productivity.

Table A-25 (continued). HPA HCP Channel Modifications Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, and overall population productivity.
	Altered groundwater–surface water interactions	Reduced available suitable habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Mussel responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Effect of groundwater exchange to mussel health and fitness is a data gap.
	Water Quality Modification								
	Altered temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent	Seasonal	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Host-fish of the California floater and Western ridged mussel may be affected by increased temperatures, which may lead to mortality or increased thermal stress and decreased fitness of host fish. Juveniles and adults: Mortality due to increased temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect all life history stages.
	Altered suspended sediments and turbidity	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered dissolved oxygen levels	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term during channel adjustment and establishment of riparian vegetation.	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels. Juveniles and adults: A physiological response to exposure at toxic levels, causing mortality or injury leading to reduced fitness is a data gap.	Avoid sediment pulses. Limit nutrient inputs. Other mechanism specific measures as appropriate.	May affect survival of larvae. May affect juvenile survival and adult survival and productivity.