Appendix A – Exposure/Response Matrices

Introduction

This appendix provides the exposure/response matrices for the HCP species potentially affected by the various fish passage subactivity types addressed in this white paper. The list of HCP species addressed in this white paper series includes a number of marine species that are either: (1) not affected by the subactivity types addressed in this paper, or (2) are exposed but to effects explicitly addressed in other white papers (e.g., construction and operation of tidegates). In the interest of readability, the matrices were developed only for those HCP species that may experience potential stressor exposure. These include the following:

Common Name	Series Matrix Number	Matrix in this Appendix
Chinook salmon	A-1	Yes
Coho salmon	A-2	Yes
Chum salmon	A-3	Yes
Pink salmon	A-4	Yes
Sockeye salmon	A-5	Yes
Steelhead	A-6	Yes
Coastal cutthroat trout	A-7	Yes
Redband trout, westslope cutthroat trout	A-8	Yes
Bull trout, Dolly Varden	A-9	Yes
Pygmy whitefish	A-10	Yes
Olympic mudminnow	A-11	Yes
Lake chub, leopard and Umatilla dace, margined sculpin, mountain sucker	A-12	Yes
Pacific lamprey, river lamprey, Western brook lamprey	A-13	Yes
Green sturgeon, white sturgeon	A-14	Yes
Eulachon, longfin smelt	A-15	No
Pacific sand lance, surf smelt	A-16	No
Pacific herring	A-17	No
Lingcod	A-18	No
Pacific cod, Pacific hake, walleye pollock	A-19	No
Black, bocaccio, brown, canary, China, copper, greenstriped, quillback, redstripe, tiger, widow, yelloweye, and yellowtail rockfish	A-20	No
Olympia oyster	A-21	No
Northern abalone	A-22	No
Newcomb's littorine snail	A-23	No
Giant Columbia River limpet,	A-24	Yes
Great Columbia River spire snail		
California floater (mussel), Western ridged mussel	A-25	Yes

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culve	rts (removed/replac	ed/retrofitted for fish pass	age)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual-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 Modifications.	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 Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully. <u>Juveniles</u> :Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure. <u>Adults</u> :Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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.
	Stream bed 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. <u>Adults</u> : 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 egg and alevin survival. 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-		Exposure									
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism		
		Loss of habitat access (during construction and maintenance or dam removal)	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 eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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 egg and alevin survival. May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.		
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.		
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Aquatic Vegetation Modifications.		
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.		
	Water Quality Modifications	_	_			_	-	-	-		
		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:Decreased survival 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 egg and alevin survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.		

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

Sub-	Torres of March 2019	_	Ex	posure	1	r	_		
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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. <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 or dewatering of culvert induced impoundments where practicable.	May affect egg, alevin, and juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (depending on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-1	(continued).
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Sub-			Exj	posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Riparian Vegetation Modifications			-	-	-				
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removal/ replacement/ retrofit of a structure for fish passage purposes is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to	Eggs and alevins; Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible. May affect behavior. Adults However, riparian modification resulting from removal/ replacement/ retrofit of a structure for fish passage purposes is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to May affect surviva fitness during juver intermediate-term provide the greatest extent possible.	Stressors related to extensive modification of iparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removal/ replacement/ retrofit of a structure for fish passage purposes is expected to be imited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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	be similarly minor across all submechanisms.			
	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				
	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				
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults				
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Sub-			Exj	posure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Aquatic Vegetation Modifications		<u>.</u>		<u>.</u>			<u>.</u>	•		
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by removing/ replacing/	Design: Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.		
	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	retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.			
	Hydraulic & Geomorphic Modifications										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.		
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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				

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-		-				
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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 alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <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 cause direct injury or mortality of eggs, alevins, 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	<u>Eggs and alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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 egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg and alevin survival. May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-1	(continued).
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Sub-	Exr		posure	2					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								•
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<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.

Table A-1	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure	1				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May cause direct mortality in acute events. May affect juvenile survival and fitness as well as adult survival and spawning productivity.
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual-decadal (depending on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-1	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications	-	-	-	-	-	-	-	
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered stream bank and shoreline 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	extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	and sta success Juvenil velocit in decr change	and stability, leading to decreased incubation success and alevin survival.project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This mayproject. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.			
	Altered substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		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.	ıy nd g	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	<u>-</u>	-	<u>-</u>	-		-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure	1				
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. <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 cause direct injury or mortality of eggs, alevins, juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-	Sub-								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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: Cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins.Juveniles and adults: 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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications			· _					
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 and alevins:Decreased incubationsuccess due to decreased redd dissolvedoxygen as described for related stressorresponses under Water Quality Modifications.Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition and resultingeffects on growth and fitness. Potentialhabitat avoidance and/or injury and mortalitycaused by excessive turbidity as described forrelated stressor responses under Water QualityModifications.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModifications.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModifications.	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	<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 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	<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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Decreased incubationsuccess.Juveniles and adults:Decreased availabilityof thermal refuge habitat, limiting juvenilesurvival, growth, and fitness.May limit adultsurvival and spawning productivity.Adults:Decrease in suitable spawninghabitat, increased competition, decreasedspawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Sub-	Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications				<u>.</u>	-			
	Altered autochthonous 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.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Seasonal	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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-			-		-	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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-decadal (depending on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish are not 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 cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and alevin life-history stages. 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	<u>Juveniles</u> : 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.

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Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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. <u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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 during egg and alevin life-history stages. May affect growth and fitness at juvenile life- history stage, mortality at all life- history stages, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications						-	-	-
		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:Decreased survival 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 during egg and alevin life-history stages. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect survival of incubating eggs and alevins. May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	During construction	Short-term	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance activities	Short-term	Interannual-decadal (dependent on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
נ	Riparian Vegetation Modifications								

	Impact Mechanism/ Submechanism		Ex	posure					
ty		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 and alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modifications. 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 Modifications. 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 Modifications.	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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	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.		May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Altered channel geometry Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability Altered flow regime Altered substrate Composition Altered groundwater-surface water exchange	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the spawning productivity.	May affect survival at egg, alevin, 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 Adults Continuous	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	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 substrate composition		Year round	Permanent			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		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Sub-			Exj	posure	_	_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	<u>.</u>	<u>.</u>	<u>.</u>	÷	<u>.</u>	·	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implicationa for nonvigiting productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	and diversity. <u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

ıb-			Ex	posure					
ctivity Гуре	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Trap a	p and Haul Operations								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-			-		
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	Juveniles; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chinook Salmon.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure	_	_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replac	ed/retrofitted for fish passa	ge)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		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 Modifications.	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 Modifications.

Sub-	Impost Mashanism/		Exj	posure	7	T			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
handling	Dewatering and fish handling	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. <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 cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure	1				
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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. <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 or dewatering of culvert induced impoundments where practicable.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
Sub-			Ех	xposure					
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activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Coho Salmon.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications		<u>.</u>	-		-	-	-	
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removal/ replacement/ retrofit of a structure for fish passage purposes is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all submechanisms.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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	be similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
		·			<u>.</u>		·	<u>.</u>	

Sub-			Exp	posure					
ictivity Гуре	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	•		-	<u>.</u>	-	<u>.</u>	-	<u>.</u>
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by removal/ replacement/	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.
	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	retrofit of a structure for fish passage purposes is expected to be limited in extent in comparison to initial installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		and stability, leading to decreased incubation success and alevin survival.project. Enco designs that m channel geometry, flow substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This mayproject. Enco designs that m channel geometry groundwater e extent practical	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 substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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		

Table A-2 (continued).	,
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-	-	-	-	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure		·			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 decreased 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning 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	<u>Juveniles</u> : 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-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 pH levels	During construction	Short-term	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During construction	Short-term	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate the potential effects of expanded fish passage on eutrophication. Reduce anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance activities	Short-term	Interannual-decadal (depending on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-2	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Coho Salmon.

Sub-			Fv	nosura					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications		-	-	-		-	-	-
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered stream bank and shoreline 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		e Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	

Table A-2	(continued)
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Sub-		Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Hydraulic & Geomorphic Modifications	-	-	-	-		-	-	-	
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel Carefully evaluate project siting and M morphology, flow velocity, and substrate design and consider the magnitude of ju composition can alter substrate composition impact mechanisms produced by the st	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.		
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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		xct t	
	Altered substrate composition		Year round	Permanent	Continuous		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.			
	Altered groundwater- surface water exchange	Ye str occ egg juv	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous					

Table A-2 (continued).	
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation					<u>-</u>	<u>.</u>	<u>.</u>	<u>.</u>
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-	Exposure				Develting Effects of the				
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Failure to capture and relocate fish may leadto mortality from stranding.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-	b- Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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 towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-			Ех	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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 towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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 eggs and alevins. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-	Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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	and alevins;Eggs and alevins:Decreased includationAvoid/minimize disturbance ofniles;success due to decreased redd dissolvedriparian vegetation. Maintain systemtsoxygen as described for related stressorresponses under Water Quality Modifications.Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition and resultingeffects on growth and fitness. Potentialhabitat avoidance and/or injury and mortalitycaused by excessive turbidity as described forrelated stressor responses under Water QualityModifications.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModifications.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModifications.		May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and 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	<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 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	<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.	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 exchange	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. <u>Adults</u> : 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, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Sub-			Exp	oosure				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modifications		-	-	-			_
	Altered autochthonous 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.	De foo aqu ext <u>Co</u> dis
	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.	dur
	Hydraulic & Geomorphic Modifications							
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Car des imp
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Aduits	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	pro des cha sub gro ext
	Altered substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.	

Minimization Measures	Resulting Effects of the Submechanism
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation	May affect juvenile growth and fitness.
ring project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.

Table A-2 (continued).	,
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		•		<u>.</u>	-	<u>.</u>	<u>.</u>	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	rposure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								-
	Equipment operation and materials placement	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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Ex	posure		1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 are not 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 cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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)	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, 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 growth and fitness at juvenile life-history stage, mortality at all life-history stages, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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.

Sub-	· / · · /		Ex	posure	1	Ì			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect survival of incubating eggs and alevins. May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance activities	Short-term	Interannual-decadal (dependent on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								

Table A-2 (contin	ued).
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ub-			Ex	posure	1	1	_		
ctivity Sype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shading, solar input and ambient air temperature	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 towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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 and shoreline 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 and alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modifications. 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 Modifications. <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 Modifications.	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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.
	Aquatic Vegetation Modifications		·	•		•			

HPA HCP Fish Passage Structures Exposure and Response Matrix for Coho Salmon.

Sub-			Exp	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitabilityYear-round (with stressor exposure occurring during high-flow events, fall through spring)Year round	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	a s J v v in c c li c d d <u>A</u> k a a t t s s a g d d r r a o o a	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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Table A-2 (continued).	
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Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-	-	-	-	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-	Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Trap a	nd Haul Operation	S					spawning productivity.		
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. <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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-		-	-		
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	<u>All exposed life-history stages</u> : Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	J <mark>uvenile</mark> s; Adults	<u>All exposed life-history stages</u> : Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Coho Salmon.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replac	ced/retrofitted for fish passa	ge)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		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 Modifications.	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 Modifications.

Sub-			[Ex]	posure	1	ï			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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/orsedimentation, resulting in decreasedincubation 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.
		Stream bed 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 migrating juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure		r			
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenile</mark> s; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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; Adults	<u>Eggs and alevins:</u> Decreased survival due to winter ice formation and scour. <u>Adults</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. 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 adult survival and spawning productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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 or dewatering of culvert induced impoundments where practicable.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chum Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution.
	Altered stream bank and shoreline 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	similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	•		•	<u>.</u>		-	<u>.</u>	•
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by removing/ replacing/	Design: Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.
	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	retrofitting structures for fish passage is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability for adult migration and spawning, and juvenile holding and	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime	migration	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can affect migration rates, predation exposure, and other parameters, affecting survival, growth and	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 substrate composition and stability		Year round	Permanent	Continuous		fitness. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Permanent	Continuous		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.		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	÷	<u>.</u>		<u>.</u>	•	<u>.</u>	<u>.</u>
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. Juveniles: Juveniles may be denied the ability to migrate downstream in certain circumstances. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Altered habitat complexity may alter migratory corridors and holding areas, leading to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Fish La	adders/Fishways			I	I	I			
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

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Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
H a	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 juveniles exposed to sediment pulses, migration delay, and increased predation risk. <u>Adults</u> : 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 survival, 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	<u>Juveniles</u> : 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-			Ex	posure					
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activity Type	Impact Mechanism/ Submechanism	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range. <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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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: Cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins.Juveniles and adults: 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate the potential for fish passage projects to contribute to eutrophication. Address anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual-decadal (dependent on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-3 (continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Chum Salmon.

Sub-	· · · · · · · · · · · · · · · · · · ·		Ex	posure					
ıctivity Гуре	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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		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 juvenile survival, growth, and fitness. 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Table A-3	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Chum Salmon.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	•	•	<u>.</u>	•	<u>.</u>	<u>.</u>	-	-
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, and reduced spawning and 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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	suitability, and reduced spawning and habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Adults	and stability, leading to decreased incubation success and alevin survival.project. designsJuveniles: Altered channel geometry, flow velocity, and substrate composition can result in altered migratory and holding habitat complexity. This may increase predationsubstrate groundw extent predation	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 substrate composition		Year round	Permanent	Continuous		exposure and alter migratory behavior, leading to decreased growth, fitness, and survival.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Permanent	Continuous		Addits: Changes in channel horphology 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.		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	<u> </u>	-		<u>.</u>	-	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure	1				
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Failure to capture and relocate fish may lead to mortality from stranding. <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 cause direct injury or mortality of eggs, alevins, juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 migrating juveniles exposed to sediment pulses, migration delay, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chum Salmon.

Sub-	/ Impact Mechanism/		Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications			·					
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 and alevins:Decreased incubationsuccess due to decreased redd dissolvedoxygen as described for related stressorresponses under Water Quality Modifications. <u>Juveniles:</u> Decreased refuge habitatavailability and foraging opportunities,leading to increased competition and resultingeffects on growth and fitness. Potentialhabitat avoidance and/or injury and mortalitycaused by excessive turbidity as described forrelated stressor responses under Water QualityModifications.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModifications.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, responses under Water QualityModifications.	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 juvenile survival, growth, and fitness. 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	<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 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	<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.	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 exchange	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. <u>Adults</u> : 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, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

	Exposure						
Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Aquatic Vegetation Modifications							
Altered autochthonous 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.	De foc aqu ext <u>Co</u> dis
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.	dur
Hydraulic & Geomorphic Modifications							
Altered channel geometry	Change in migratory habitat structure and habitat suitability, and reduced spawning habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Car des imj
Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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 migration habitat suitability. This may alter migration timing and/or	pro des cha sub gro ext
Altered substrate composition		Year round	Permanent	Continuous	_	increase predation exposure leading to decreased growth, fitness, and survival.	
Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and adult migration)	Permanent	Continuous		<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	

Minimization Measures	Resulting Effects of the Submechanism
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esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation	May affect juvenile growth and fitness.
rring project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
arefully evaluate project siting and esign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project esigns that minimize effects on nannel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		<u>-</u>	Ţ	<u>-</u>	L		-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure	1	1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable migration holding habitats may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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 alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish are not 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 cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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 egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by migrating juveniles exposedto sediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning 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	<u>Juveniles</u> : 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-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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, mortality and increased predation risk. <u>Adults</u> : 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 growth and fitness at juvenile life-history stage, mortality at all life-history stages, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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: Decreased survival 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. <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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chum Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect survival of incubating eggs and alevins. May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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 that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance activities	Short-term	Interannual-decadal (dependent on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								

Torres (March 199	•/	_	Ex	posure	ŕ	r			Doculting Effects of the
Submechanis	sm/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Altered shading, sol and ambient air tem	ar input perature	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:Decreased survival 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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Altered stream bank shoreline stability	and	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 and alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modifications. 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 Modifications. <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 Modifications.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Altered allochthono inputs	us	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	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 survival, growth, and fitness.
Altered habitat com	plexity	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	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.	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 groundwate surface water excha	r– nge	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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-3 (continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Chum Salmon.

Sub-	Impact Machanism/		Exp	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced 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.		May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and migration	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	holding habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Addits	and stability, leading to decreased incubation success and alevin survival.p <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can alter migratory pathways and behavior. This may delay or speed migration unfavorably, and/or increase predation exposure, leading to decreased growth, fitness, and survival.p	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 substrate composition		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and adult migration)	Permanent	Continuous		<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.		

)-			Ex	posure					
ivity pe	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	·	-		-	-	<u>.</u>	÷	<u>.</u>
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable migration holding habitats may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Trap a	nd Haul Operation	S							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-		-	-
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	Juveniles; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Chum Salmon.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replac	ed/retrofitted for fish passa	age)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		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 Modifications.	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 Modifications.

Sub-			Ex	posure		ŕ			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, 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	<u>Eggs and alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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.
		Stream bed 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 migrating juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
	Water Quality Modifications								
		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; Adults	Eggs and alevins: Decreased survival due to winter ice formation and scour. <u>Adults</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. 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 adult survival and spawning productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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. <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 or dewatering of culvert induced impoundments where practicable.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-4	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Pink Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications					-			
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution.
	Altered stream bank and shoreline 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	similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Pink Salmon.

Sub-			Ex	posure	_	_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	-	-						
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.
	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		during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability for adult migration and spawning, and juvenile holding and migration	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	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		and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can affect migration rates, predation exposure, and other parameters, affecting survival, growth and	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 substrate composition and stability		Year round	Permanent	Continuous		fitness. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Permanent	Continuous		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.		

Table A-4 (o	continued).
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Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-	-	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Inveniles</u> : Juveniles may be denied the ability to migrate downstream in certain circumstances. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	And diversity.All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Altered habitat complexity may alter migratory corridors and holding areas, leading to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Fish L	adders/Fishways					•			
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 juveniles exposed to sediment pulses, migration delay, and increased predation risk. <u>Adults</u> : 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 survival, 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	<u>Juveniles</u> : 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-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range. <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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential effects of increased passage on eutrophication. Address anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-4	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Pink Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications		-	-					
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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		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 juvenile survival, growth, and fitness. 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

	Exp	posure					
Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
l food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
l food web productivity, reduced ; opportunity, reduction in available	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults		during project construction.	
in habitat structure and habitat ty, and reduced spawning and availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Year-round (with stressor exposure occurring during high-flow events, fall through spring) Year round	Permanent Permanent	Seasonal	Aduits	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in altered migratory and holding habitat complexity. This may increase predation exposure and alter migratory behavior, leading to decreased growth, fitness, and survival.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Year-round (with stressor exposure occurring during egg incubation)	Permanent	Continuous		<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.		

Sub-			Exp	oosure	Y									
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism					
	Aquatic Vegetation Modifications	Aquatic Vegetation Modifications												
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.					
	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		during project construction.						
	Hydraulic & Geomorphic Modifications													
	Altered channel geometry	Change in habitat structure and habitat suitability, and reduced spawning and 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 altered migratory and holding habitat complexity. This may increase predation	Carefully evaluate project siting and design and consider the magnitude of j 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 spawning productivity.					
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal									
	Altered substrate composition		Year round	Permanent	Continuous	-	exposure and alter migratory behavior, leading to decreased growth, fitness, and survival.							
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Permanent	Continuous		<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.							

Table A-4	(continued).
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation			-		-			-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Failure to capture and relocate fish may leadto mortality from stranding.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of eggs, alevins, juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
Sub-			Ex	posure					
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activity Type	Impact Mechanism/ Submechanism	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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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. <u>Adults</u> : 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 migrating juveniles exposed to sediment pulses, migration delay, and increased predation risk. <u>Adults</u> : 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance activities	Short-term	Interannual-decadal (dependent on maintenance frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure	7				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 and alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modifications. 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 Modifications. 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 Modifications.	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 juvenile survival, growth, and fitness. 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	<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 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	<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.	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 exchange	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. <u>Adults</u> : 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, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Table A-4	(continued).
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			Exj	posure	,			
	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
A	Aquatic Vegetation Aodifications							
A p	Altered autochthonous 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.	De fo aq ex <u>Ce</u> di
A	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.	du
H N	Iydraulic & Geomorphic Aodifications							
A	Altered channel geometry	Change in migratory habitat structure and habitat suitability, and reduced spawning habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	<u>Eggs and alevins</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Ca de im
A	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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 migration habitat suitability. This may alter migration timing and/or	pro de ch su gr ex
A c	Altered substrate omposition		Year round	Permanent	Continuous		increase predation exposure leading to decreased growth, fitness, and survival.	
A s	Altered groundwater- urface water exchange		Year-round (with stressor exposure occurring during egg incubation and adult migration)	Permanent	Continuous		<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.	

Minimization Measures	Resulting Effects of the Submechanism
	-
esign: Limit project structural opprint to minimize shading of uatic vegetation to the greatest tent practicable. <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation	May affect juvenile growth and fitness.
ring project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	<u>-</u>	-	-	-	<u>.</u>	-	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable migration holding habitats may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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 alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish are not 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 cause direct injury or mortality of eggs, alevins, 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	<u>Eggs and alevins, 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 cause direct mortality or injury at egg, alevin, and juvenile life-history stages. 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 egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by migrating juveniles exposedto sediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning 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	<u>Juveniles</u> : 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.

			Ex	posure	·	·		
у	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	L gi es ai
		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, mortality and increased predation risk. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	L gı es Po al ha
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	A cı sł
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	L st gi pi
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modifications.	A ba
	Water Quality Modifications							
-		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:Decreased survival 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.	Av rip ap the

Minimization Measures	Resulting Effects of the Submechanism
mit area of dewatering to the eatest extent practicable. Follow ablished protocols for dewatering d rewatering.	See effects for related stressors under Water Quality Modifications.
mit area of dewatering to the eatest extent practicable. Follow ablished protocols for dewatering. rform slow dewatering activities to ow for movement into suitable bitats.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage, mortality at all life-history stages, and adult spawning fitness and productivity.
void fill or, if unavoidable, restore rrently filled or degraded shallow oreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
mit dredging-related disturbance of omerged aquatic vegetation to the eatest extent practicable through oject siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
oid turbidity effects above ckground levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
roid/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to greatest extent possible.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	xposure	T				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect survival of incubating eggs and alevins. May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require a TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications		1	1	1	1	1	1	

1b-			Ex	posure	1				
ype	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered shading, solar input and ambient air temperature	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: Decreased survival 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. <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 juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 and alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modifications. 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 Modifications. <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 Modifications.	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 juvenile survival, growth, and fitness. 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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.
	Aquatic Vegetation Modifications					•			

Table A-4	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Pink Salmon.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and migration	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	holding habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can alter migratory pathways and behavior. This may delay or speed migration unfavorably, and/or	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 substrate composition		Year round	Permanent	Continuous		increase predation exposure, leading to decreased growth, fitness, and survival.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and adult migration)	Permanent	Continuous		Adutts: 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.		

Table A-4	(continued).
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)-			Ex	posure					
vity De	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	•					-		·
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles:Decreased availabilityof suitable migration holding habitats maylead to decreased survival, growth, andfitness.Adults:Decreased availability of desirableresting and spawning sites due to effects onhabitat complexity may affect survival andspawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Trap a	nd Haul Operation	S							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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. <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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor			
	Ecosystem Fragmentation									
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Op min bar (i.e ups wh mią		
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	Juveniles; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Eva req ens div		

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pink Salmon.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Minimization Measures	Resulting Effects of the Submechanism					
perate trap and haul programs to mic volitional passage around rriers to the greatest extent possible e., release fish immediately stream and downstream of barriers here practicable and consistent with gratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.					
aluate the operational plan and puire monitoring where necessary to sure that the full range of life-history versity is expressed.	May affect population diversity and spatial structure.					

Sub-			Exj	posure		_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replac	ed/retrofitted for fish pass	age)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		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 Modifications.	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 Modifications.

Sub-			Ex	posure	η	1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
handling	Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully. <u>Juveniles</u> :Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure. <u>Adults</u> :Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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	<u>Eggs and alevins, 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 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/orsedimentation, resulting in decreasedincubation 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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. <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 or dewatering of culvert induced impoundments where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Sockeye Salmon.

Sub-			Ex	posure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications							-	-
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all	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 for intermediate-term period.
	Altered stream bank and shoreline 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	submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Sub-			Exp	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	-	•		<u>.</u>	-		-	
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by remaining/	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.
	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	retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition and stability		Year round	Permanent	Continuous	-	limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-	-	-	-		-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure	1	1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways.								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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. <u>Adults</u> : 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	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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-			Ex	posure		_			
activity Type	Impact Mechanism/ Submechanism	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications			·					
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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.

Sub-	Exp		posure	1	1				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential for increased passage to adversely affect eutrophication. Address anthropogenic sources of nutrient pollution to compensate	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications	-	-		•	-			-
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 stream bank and shoreline 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		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 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

		Exj	posure				Descritting Difference of the	
Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Aquatic Vegetation Modifications	-							
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	Altered dissolved oxygen levels due to reduced photosynthesis	ered dissolved oxygen levels due to aced photosynthesis Year-round (most pronounced in spring and summer when vegetation growth is most extensive) Permanent Seasonal Juveniles; Adults	during project construction.					
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			
Hydraulic & Geomorphic Modifications								
Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Addits	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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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		

HPA HCP Fish Passage Structures Exposure and Response Matrix for Sockeye Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-	<u>.</u>	-	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Appendix A Table A-5 Page 14 of 30

Sub-Exposure activity Impact Mechanism/ Submechanism Stressor When Duration Life-history Form **Response to Stressor** Туре Frequency **Roughened Channels Construction and Maintenance Activities** Eggs and alevins; Equipment operation and Increased underwater noise levels Temporary (auditory Interannual to During project <u>All life-history stages</u>: Stressor response Av materials placement construction and masking) to shortdecadal (during im dependent on noise magnitude and project-Juveniles; NC maintenance term (hearing project construction specific environmental conditions; may range Adults activities threshold effects) and maintenance) from: ha dr 0 Rupture of egg membrane. Us Fatal injury from barotrauma or 0 red permanent auditory tissue damage limiting to survival. cor Increased predation risk and decreased foraging success due to auditory masking and 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 0 responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Lir Visual and physical disturbance Interannual to Juveniles; All exposed life-history stages: Startle During project Temporary decadal (during construction and responses, increased stress. Behavioral in Adults maintenance construction and avoidance of affected habitats while spe maintenance) disturbance is ongoing. activities Adults and juveniles: Auditory masking or Em Altered ambient noise levels During project Temporary (auditory Interannual to Juveniles; masking) to shortdecadal (during temporary hearing threshold effects may construction and Adults term (hearing increase risk of predation and/or decrease maintenance project construction and threshold effects) and maintenance) foraging efficiency due to decreased ability to per activities sense predators and/or prey. Us Flow bypass, fish handling, Fish removal, relocation, and exclusion During project Short-term Interannual to Eggs and alevins; Eggs and alevins: Mortality, injury, or stress and channel rewatering decadal (depending from capture, handling, and relocation. Egg Fis construction and Juveniles; maintenance relocation is impractical, likely leading to on activity avo Adults mortality. activities frequency) 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.

Table A-5 (continued).

Minimization Measures	Resulting Effects of the Submechanism
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.
Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 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/orsedimentation, resulting in decreasedincubation 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-			Fx	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Sockeye Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Dike and levee construction 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.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 Modifications. 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 Modifications. 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 Modifications.	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 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	<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 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	<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.	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 exchange	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. <u>Adults</u> : 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, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Table A-5	(continued).
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vity De	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications								
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	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 Modifications.	during project construction.	See effects for related stressors under Water Quality Modifications.
	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		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
							and spawning success due to decreased availability of suitable migratory and spawning habitat.		
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous	_	limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	<u>.</u>		•	-	-		<u>.</u>
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.
Sub-			Ex	posure					
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activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages: See responses to related stressors under Water Quality Modifications.	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 Modifications.
		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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-		exposure			1				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish are notcaptured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Table A-5	(continued).
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Sub-			Ex	posure	1				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		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, mortality and increased predation risk. <u>Adults:</u> 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, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Sockeye Salmon.

Sub-			Ex	posure		_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Weir construction 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.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
נ ז	Riparian Vegetation Modifications								

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HPA HCP Fish Passage Structures Exposure and Response Matrix for Sockeye Salmon.

	Impact Mechanism/		Exj	posure	1				
ty	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 Modifications. 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 Modifications. <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 Modifications.	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 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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.

Working Draft–Do Not Cite Fish Passage

Table A-5	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Sockeye Salmon.

Sub-			Exp	oosure	r				
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	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 for altered dissolved oxygen under Water Quality Modifications.	during project construction.	See effects for related stressors of altered dissolved oxygen under Water Quality Modifications.
	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.		May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	- Aduns	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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		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.	ased growth, fitness, and survival. <u>ts</u> : Changes in channel morphology may to alteration of the migratory corridor and uction in suitable resting habitat, leading creased stress and decreased spawning ess. Changes in substrate composition tability resulting from altered channel netry and flow velocity may lead to eased spawning success (e.g., through ction in suitable spawning locations or increased scour and/or sedimentation dds) if potential spawning habitat is ted	

Sub-			posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		<u>.</u>	<u>.</u>		<u>.</u>		·	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
							<u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.		
Trap a	and Haul Operation	IS							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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. <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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-	Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-					
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not cantured	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	J <mark>uvenile</mark> s; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Sockeye Salmon.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects?

Sub-			Exp	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replace	ed/retrofitted for fish passag	e)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		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 Modifications.	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 Modifications.

Sub-			Ex	posure	1	1			
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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	<u>Eggs and alevins, 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 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/orsedimentation, resulting in decreasedincubation 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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. <u>Adults</u> : 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 effect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
	Water Quality Modifications								
		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: Decreased survival 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. <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 dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term	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 or dewatering of culvert induced impoundments where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-	ub-		Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								-
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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	similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		-	<u>.</u>	-			<u>.</u>	<u>.</u>
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by removing/ replacing/	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.
	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	retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	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;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	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		and stability, leading to decreased incubation success and alevin survival.proj desiJuveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This mayproj	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 substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		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.		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	<u>.</u>	<u>.</u>	<u>.</u>		-	<u>.</u>	<u>.</u>
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish La	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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 alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <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 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	<u>Eggs and alevins, 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 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 egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

Sub-			E	xposure	1				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<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.

Table A-6	(continued).
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Sub-			Ex	posure	1				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential for increased passage to adversely affect eutrophication. Reduce anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Exj	posure	1	I			
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications		-	-	-	-	-	-	-
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 stream bank and shoreline 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		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 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	

Table A-6	(continued).
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Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications						-		-
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime availability and s	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		Additis 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.	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 substrate composition		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Sub-			Ex	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Ecosystem Fragmentation											
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.			
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages:All exposed life-history stages:Reducedsupply of allochthononous nutrients can havea profound effect on food web productivity,with long-term implications.Reducedabundance and availability of primary preyitems is the most immediate effect, resultingin decreased survival, growth, and fitness.Over the long-term, riparian function canbecome diminished as nutrients are exportedfrom the system and not replaced fromallochthonous sources.This can lead torelated effects on habitat complexity,influencing the availability of resting andspawning habitat, affecting adult spawningfitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.			

Sub-Exposure activity Impact Mechanism/ Submechanism Stressor When Duration Life-history Form **Response to Stressor** Туре Frequency **Roughened Channels Construction and Maintenance Activities** Eggs and alevins; Equipment operation and Increased underwater noise levels Temporary (auditory Interannual to During project <u>All life-history stages</u>: Stressor response А materials placement construction and masking) to shortdecadal (during im dependent on noise magnitude and project-Juveniles; N maintenance term (hearing project construction specific environmental conditions; may range Adults activities threshold effects) and maintenance) from: ha dr 0 Rupture of egg membrane. Us Fatal injury from barotrauma or 0 ree permanent auditory tissue damage limiting to survival. co En Increased predation risk and decreased foraging success due to auditory masking an 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 0 responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Li Visual and physical disturbance Interannual to Juveniles; All exposed life-history stages: Startle During project Temporary decadal (during construction and responses, increased stress. Behavioral in Adults maintenance construction and avoidance of affected habitats while sp maintenance) disturbance is ongoing. activities Adults and juveniles: Auditory masking or En Altered ambient noise levels During project Temporary (auditory Interannual to Juveniles; masking) to shortdecadal (during temporary hearing threshold effects may construction and sui Adults term (hearing increase risk of predation and/or decrease maintenance project construction an threshold effects) and maintenance) foraging efficiency due to decreased ability to pe activities sense predators and/or prey. Us Flow bypass, fish handling, Fish removal, relocation, and exclusion During project Short-term Interannual to Eggs and alevins; Eggs and alevins: Mortality, injury, or stress and channel rewatering decadal (depending from capture, handling, and relocation. Egg Fis construction and Juveniles; maintenance relocation is impractical, likely leading to on activity av Adults mortality. activities frequency) 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.

Minimization Measures	Resulting Effects of the Submechanism
void pile-driving noise in excess of npact thresholds established by OAA Fisheries and USFWS in bitats used by species. Limit pile iving to in-water work windows. se double-confined bubble curtain to duce sound pressure, or work within onfined or dewatered work areas. neourage use of vibratory hammers d 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.
mit disturbance-causing activities to -water work windows when affected ecies is least likely to be present.	May affect behavior.
nploy appropriate BMPs to insulate rface waters from equipment noise id vibration occurring over extended priods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
se protocols established by NOAA sheries and WDFW/WSDOT to oid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub-							
Clivity Cype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
		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.
		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. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.
		Stream bed 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. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk.
							<u>Adults</u> : Potential migration barrier and delay,

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

foraging success, mortality.

Minimization Measures	Resulting Effects of the Submechanism
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.
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.
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.
Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 cycling	Year-round	Permanent	Continuous	Éggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 Modifications.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 Modifications.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 Modifications.	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 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	<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 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	<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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Decreased incubationsuccess.Juveniles and adults:Decreased availabilityof thermal refuge habitat, limiting juvenilesurvival, growth, and fitness.May limit adultsurvival and spawning productivity.Adults:Decrease in suitable spawninghabitat, increased competition, decreasedspawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Sub-			Ex	oosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		-	-	-	-		-	-
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous	-	limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-				-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure		γ			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish are notcaptured and relocated successfully. <u>Juveniles</u> :Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Table A-6	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

Sub-			Ex	posure	1	T			
activity Type	Impact Mechanism/ Submechanism	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)	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, mortality and increased predation risk. <u>Adults:</u> 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, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

Sub-			Ех	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications			1				1	

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

		Ex	posure	1	1			
Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Altered shading, solar input and ambient air temperature	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:Decreased survival 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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
Altered stream bank and shoreline 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 Modifications. 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 Modifications. <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 Modifications.	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 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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.

Working Draft–Do Not Cite Fish Passage

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

Sub- activity Type	Impact Mechanism/ Submechanism	Exposure							
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous 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.	Design:Limit project structuralfootprint to minimize shading ofaquatic vegetation to the greatestextent practicable.Construction:Avoid/minimizedisturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	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 channelCarefully evaluate pr design and consider t impact mechanisms p project.morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.Carefully evaluate pr design and consider t impact mechanisms p project.Juveniles:Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity.Carefully evaluate pr design and consider t impact mechanisms p project.Eggs and alevins:Carefully evaluate pr design and consider t impact mechanisms p project.European StructureSubstrate composition can result substrate composition groundwater exchange extent practicable.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
A c S	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal			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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		
Sub-			Ex	posure					
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activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation			-	<u>.</u>	<u>.</u>	<u>.</u>	<u>.</u>	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	and diversity. <u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Trap a	and Haul Operation	S							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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. <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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-			-		
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not cantured	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	J <mark>uvenile</mark> s; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Steelhead Trout.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects?

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replace	ed/retrofitted for fish passag	e)		·				
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		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 Modifications.	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 Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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	<u>Eggs and alevins, 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 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. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-	Ex Ex		posure	1	T				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	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. <u>Adults</u> : 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 effect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								•
		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: Decreased survival 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. <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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Cutthroat Trout.

Sub-			Ex	posure	1	1			
аспуцу Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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. <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 or dewatering of culvert induced impoundments where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications			-	-	-			
	Altered shading, solar input, and ambient air temperature	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;Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages.Avoid riparia appro the grAdultsHowever, riparian modification resulting from removing/ replacing/ retrofitting structures for fish passage is expected to be limited in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across allAvoid riparia paria paria paria	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from removing/ replacing/ retrofitting structures for fish passage is expected to be limited in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all	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 for intermediate-term period.
	Altered stream bank and shoreline 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	submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
		•							•

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications			-		-	-		
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by removing/ replacing/	Design: Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.
	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	retrofitting structures for fish passage purposes is expected to be limited in comparison to initial installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	hannel 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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	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		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	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 substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Ex	posure		_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-	-	-		-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	and diversity. <u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure		1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure		r			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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. <u>Adults</u> : 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	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<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.

inting TypeImpact Mechanism/ SubmechanismStressonWenDurationFrequencyLife-bisory FomResponse OSTessonMininization MeasuresTypeSubmechanismIncreased subjectDependent on contributing mechanism of impact)Temporary toshort interamula-decadad impact)Intermitert to interamula-decadad contributing mechanism of impact)Eges and alevins: Fags and alevins: AdultsEges and alevins: Fags and alevins: AdultsEges and alevins: Fags and alevins: AdultsEges and alevins: Fags and alevins: AdultsEnergy and alevins: adults: AdultsEnergy and alevins: AdultsEnergy and alevins: Adults <th>b-</th> <th></th> <th>Exp</th> <th>oosure</th> <th></th> <th></th> <th></th> <th></th>	b-		Exp	oosure					
Increased suspended solidsDependent on contributing mechanism of impactTemporary to short- term (dependent on contributing mechanism of impact)Intermittent to interannual-decadal (dependent on contributing mechanism of impact)Eggs and alevins: Luveniles; AdultsEngs and alevins: cause fire sediment embeddedness may lead to direct sediment embedd	tivity Impact Mechanism/ pe Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
reduced spawning success.		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. <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 pH levelsDependent on contributing mechanism of impactTemporary to short- term (depending on mechanism of impactIntermittent to interannual-decadal (dependent on contributing mechanism of impactJuveniles; AdultsJuveniles; o pH levels outside of optimal thresholds, to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.Avoid nutrient inputs where practicable. Avoid in-water curing of oracrete or discharge of concrete and and mechanism of impactJuveniles; adultsJuveniles; AdultsJuveniles; to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.Avoid nutrient inputs where practicable. Avoid in-water curing of oracrete or discharge of concrete and and and		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
Altered nutrient cyclingDuring and following discharge eventsLong-term to permanentContinuousEggs and alevins; Juveniles; AdultsNutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.Evaluate potential for increased passage to adversely affect eutrophication. Address anthropogenic sources of nutrient pollution to compensate.May fitted stag		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential for increased passage to adversely affect eutrophication. Address anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
Introduction of toxic substances (PAHs, metals, organic pollutants)During construction and maintenanceShort-termInterannual-decadal (dependent on activity frequency)All expose life-history stages: toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.Require TESC plan for all construction and maintenance activities.May fitne stag		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-7	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Cutthroat Trout.

Sub-			Exj	posure	1	1			Deculting Effects of the
аснуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications		-			-			
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The	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 stream bank and shoreline 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	extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Aquatic Vegetation Modifications							-	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	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. during project construction	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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			

HPA HCP Fish Passage Structures Exposure and Response Matrix for Cutthroat Trout.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications			-			-	-	
	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;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	in channel Carefully evaluate project siting and and substrate design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, 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	Aduits	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	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	t
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange	Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		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.			

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation			-	-	-		-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-	Turner of Marchanet and I	-	Ex	posure]	1	-		
Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Failure to capture and relocate fish may leadto mortality from stranding.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 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. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Cutthroat Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 Modifications.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 Modifications.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 Modifications.	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 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	<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 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	<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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Decreased incubationsuccess.Juveniles and adults:Decreased availabilityof thermal refuge habitat, limiting juvenilesurvival, growth, and fitness.May limit adultsurvival and spawning productivity.Adults:Decrease in suitable spawninghabitat, increased competition, decreasedspawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	-		•	<u>.</u>	- <u>-</u>	<u>.</u>	-	-
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	<u>Eggs and alevins</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Ex	xposure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
-	Ecosystem Fragmentation	-	<u>-</u>	<u>+</u>	-	-	<u>.</u>	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure	1	1			
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 decreased 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-	- / /		Ex	posure	.	Ť			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish are notcaptured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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/orsedimentation, resulting in decreasedincubation 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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)	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, mortality and increased predation risk. <u>Adults:</u> 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, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Cutthroat Trout.

Sub-			E	xposure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications	1		1			1		1

			Exj	posure					
7	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Aan	Altered shading, solar input and ambient air temperature	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: Decreased survival 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. <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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
Asl	Altered stream bank and shoreline 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 Modifications. 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 Modifications. <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 Modifications.	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.
A ir	Altered allochthonous nputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	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 survival, growth, and fitness.
A	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	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.	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.
A	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Cutthroat Trout.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous 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.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	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.		May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins:Changes in channelCarefully evaluate projmorphology, flow velocity, and substrate composition can alter substrate compositiondesign and consider the impact mechanisms proj	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal Adults Continuous	and stability, leading to decreased incubation success and alevin survival.project. Encour designs that mit channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This mayproject. Encour designs that mit channel geomet substrate compo groundwater ex extent practicab	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 substrate composition		Year round	Permanent		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival			
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous	louis	<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.	vth, fitness, and survival. ges in channel morphology may on of the migratory corridor and suitable resting habitat, leading ress and decreased spawning iges in substrate composition esulting from altered channel flow velocity may lead to wning success (e.g., through hitable spawning locations ed scour and/or sedimentation tential spawning habitat is	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-	-		-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	and diversity. <u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
							<u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.		
Trap a	nd Haul Operation	IS							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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. <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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-		-			
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	J <mark>uvenile</mark> s; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Cutthroat Trout.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Exj	posure		7			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replac	ed/retrofitted for fish passag	e)	•					
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		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 Modifications.	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 Modifications.

Table A-8. HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-			Ex	posure	T	1	_		
Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
handling	Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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/orsedimentation, resulting in decreasedincubation 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-			Ex	posure	1	1	_		
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill) to long-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. <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 or dewatering of culvert induced impoundments where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
Sub-			Ex	posure			_		
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activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, the extent of riparian modification resulting from structure removal/ replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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	be similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Sub-			Exj	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Aquatic Vegetation Modifications											
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by structure removal/	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.			
	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	replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.				
	Hydraulic & Geomorphic Modifications											
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.			
	Altered flow regime	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	t			
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival					
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.					

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-	-	-	-	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
							and diversity.		
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Exj	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.			
Fish L	adders/Fishways											
	Construction and Maintenance Activities											
	Equipment operation and materials placement	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.			
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.			
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.			

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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 alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <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 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 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. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-			Ex	xposure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	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.

activity Type Impact Mechanism/ Submechanism Impact Mechanism/ Submechanism Stressor Wen Dependent on contributing mechanism of impact Frequency Life-history Fon Response to Stressor Ensure project design avoids minimizes habitat alterations to chronic bank instability. A short-tern utribility effects at impact Impact Mechanism/ Type Increased suspended solids Dependent on contributing mechanism of impact Temporary to short term (dependent on mechanism of impact Intermitten to interanism of impact Eggs and alevins; Herendent on contributing mechanism of impact Eggs and alevins; Herendent on contributing Herendent on contributing Herendent on contributing mechanism of impact Eggs and alevins; Herendent on contributing Herendent on contributing Herendent on contributing Herendent on contributing Herendent on contributing Herendent on contributing Herendent on contributing Herendent on contributing Herendent on to chronic basic Herendent on contributing Herendent on contributing Herendent on to chronic basic Herendent on to chronic basic Herendent on to chronic basic Herendent on to chronic basic Herendent Herendent on to chroin chasic Herendent on to chroin chronic basic	Resulting Effects of the Submechanismund/orMay affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.extent shed ent and
Increased suspended solidsDependent on contributing mechanism of impactTemporary to short- term (dependent on contributing mechanism of impactIntermittent to interannual-decadal (dependent on contributing mechanism of impactIntermittent to interannual-decadal (dependent on contributing mechanism of impactEggs and alevins; fuerm (dependent on contributing mechanism of interannual-decadal (dependent on contributing mechanism of impactEggs and alevins; fuerm (dependent on contributing mechanism of impactEggs and alevins; fuerm (dependent on courtibuting mechanism of impactEggs and alevins; fuerm (dependent on protocols for managing sedim turbidity.Eggs and alevins; fuerm (dependent on protocols for managing sedim turbidity.ImpactImpactImpactImpactImpactImpactImpac	and/orMay affect survival of incubating eggseadingand alevins. May affect juvenileyoidgrowth and fitness and adultproductivity and spawning success.extentshedent and
biood 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.	
Altered pH levelsDependent on contributing mechanism of impactTemporary to short- term (depending on contributing mechanism of impactIntermittent to interannual-decadal (dependent on contributing mechanism of impactJuveniles; AdultsJuveniles; to pH levels outside of optimal thresholds, to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.Avoid nutrient inputs where practicable. Avoid in-water of contributing mechanism of impact	Iring of ete May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
Altered nutrient cyclingDuring and following discharge eventsLong-term to permanentContinuous permanentEggs and alevins; Juveniles; AdultsNutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.Evaluate potential for increase passage to adversely affect eutrophication. Address anthropogenic sources of nutr pollution to compensate.	d May affect survival, growth, and fitness at all exposed life-history stages.
Introduction of toxic substances (PAHs, metals, organic pollutants)During construction and maintenanceShort-term construction and maintenanceInterannual-decadal (dependent on 	struction May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications		-		-	-			
	Altered shading, solar input, and ambient air temperature	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	are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 stream bank and shoreline 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		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 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

		Ex	posure					
Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Aquatic Vegetation Modifications		•	-	-	-		-	-
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	
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			
Hydraulic & Geomorphic Modifications								
Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.		
Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-			
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
							the evolutionary fitness of the stock, with broad implications for population productivity and diversity.		
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Exj	posure]	I	_		
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Failure to capture and relocate fish may leadto mortality from stranding.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub- activity	Impact Mechanism/		Ex	posure					Resulting Effects of the
Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	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 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. <u>Adults</u> : 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-	v Impact Mechanism/		Ex	posure		1			
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		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. <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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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: Decreased survival 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. <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.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 Modifications.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 Modifications.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 Modifications.	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 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	<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 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	<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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Decreased incubationsuccess.Juveniles and adults:Decreased availabilityof thermal refuge habitat, limiting juvenilesurvival, growth, and fitness.May limit adultsurvival and spawning productivity.Adults:Decrease in suitable spawninghabitat, increased competition, decreasedspawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Sub-			Ex	posure			-		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		-	-	-	-			
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	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 Modifications.	during project construction.	See effects for related stressors under Water Quality Modifications.
	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.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
							<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Eggs and ale Juveniles; morphology Adults composition	<u>Eggs and alevins</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-			
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure		1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish are not 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 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 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. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-			Ex	posure	7	·			
activity Type	Impact Mechanism/ Submechanism	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)	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, mortality and increased predation risk. <u>Adults:</u> 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, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-	Lucia Mada and		Ex	posure	1	r			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications	·			·				

	.		Exj	posure	1	r			
ŗ	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
2	Altered shading, solar input and ambient air temperature	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: Decreased survival 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. <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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
2 S	Altered stream bank and shoreline 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 Modifications. 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 Modifications. <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 Modifications.	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.
i	Altered allochthonous nputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	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 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	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.	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.
s	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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-8 (continued).HPA HCP Fish Passa

Sub-			Exj	posure				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered autochthonous 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.	De foo aqu ext <u>Co</u> dis
		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 for altered dissolved oxygen under Water Quality Modifications.	dur
	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.	
	Hydraulic & Geomorphic Modifications							
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Car des
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	- Adults	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	pro des cha sub gro ext
	Altered substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.	

Minimization Measures	Resulting Effects of the Submechanism
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. onstruction: Avoid/minimize sturbance of aquatic vegetation	May affect juvenile growth and fitness.
ring project construction.	See effects for related stressors of altered dissolved oxygen under Water Quality Modifications.
	May affect juvenile survival, growth, and fitness.
arefully evaluate project siting and sign and consider the magnitude of apact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	·		-		-		-	<u>.</u>
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
							and diversity.		
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

		Ex	posure					
Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
and Haul Operation	ns							
Operational Activities								
Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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. <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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-			
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	J <mark>uvenile</mark> s; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replac	ed/retrofitted for fish passag	e)	·					
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	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. <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 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 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. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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.
	I	Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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. <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 or dewatering of culvert induced impoundments where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
		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. <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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

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Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, the extent of riparian modification resulting from structure removal/ replacement/ retrofitting for fish passage purposes is expected to be limited in extent in comparison to initial installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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	similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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Sub-		Exposure									
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Aquatic Vegetation Modifications		-		-	-		-			
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by structure	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.		
	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	removal/replacement/retrofitting for fish passage purposes is expected to be limited in comparison to initial installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.			
	Hydraulic & Geomorphic Modifications										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult spawning productivity.		
	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	– Adults	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	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	t		
	Altered substrate composition and stability		Year round	Permanent	Continuous	_	limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.				

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Sub-			Ex	posure	_							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Ecosystem Fragmentation	system Fragmentation										
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.			
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.			

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Sub-	Impact Mechanism/ Submechanism	Exposure							
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 decreased 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages: See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

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Sub-	Impact Mechanism/ Submechanism	Exposure							
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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	<u>Eggs and alevins, 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 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. <u>Adults</u> : 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	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential for increased passage to adversely affect eutrophication. Address anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-	Impact Mechanism/			posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more	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 stream bank and shoreline 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	extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Aquatic Vegetation Modifications	_					_	_	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications	-	-	-	-		-	-	-
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	·			-	-	<u>.</u>		-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	And diversity.All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ех	posure		r			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Roug	hened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Failure to capture and relocate fish may leadto mortality from stranding.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 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/orsedimentation, resulting in decreasedincubation 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 (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and alevin mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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: Cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins.Juveniles and adults: Nuveniles 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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 Modifications. 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 Modifications. 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 Modifications.	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 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	<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 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	<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.	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 exchange	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. <u>Adults</u> : 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, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		-		-	-		-	-
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	·	-	-	-	-			-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ех	cposure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles:Decreased availabilityof suitable rearing habitats and undesirableeffects on food web productivity may lead todecreased survival, growth, and fitness.Adults:Decreased availability of desirableresting and spawning sites due to effects onhabitat complexity may affect survival andspawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages: See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Table A-9 (continued).	HPA HCP Fish Passage Structures Exposure and Response Matrix for Westslope Cutthroat and R
Table A-7 (continueu).	The A net Tish I assage Structures Exposure and Response Matrix for Weststope Cuttin oat and R

Sub-		Ex	posure					
activity Impact Mechanism/ Type Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish are not 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 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 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. <u>Adults</u> : 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.
	Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

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Redband Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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)	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, mortality and increased predation risk. <u>Adults:</u> 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, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-	Torrest Markensing/	Impact Mechanism/]	ſ	_		
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 Modifications. <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 Modifications. <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 Modifications.	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 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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. <u>Adults</u> : 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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		•	-	-	<u> </u>		-	-
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		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.		

Sub-			Ex	posure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	<u>.</u>			<u>.</u>	<u>.</u>	·	·
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of alevins and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Trap a	nd Haul Operation	S							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	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. <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 cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and alevins; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation							-	
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run-	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	Juveniles; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver	rts (removed/replac	ed/retrofitted for fish passag	e)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <u>All exposed 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 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Table A-10. HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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 egg scour and/orsedimentation, resulting in decreasedincubation 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 larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed 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 eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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. <u>Adults</u> : 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 effect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	Dosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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 or dewatering of culvert induced impoundments where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
		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. <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 larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Table A-10 (continued).HPA HCP Fig

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications	_					_	-	-
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, the extent of riparian modification resulting from structure removal/replacement retrofitting for fish passage purposes is expected to be limited in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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 larvae; Juveniles; Adults	be similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish. Table A-10 (continued).

Sub-		Exposure									
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Aquatic Vegetation Modifications		-	-	-	-		-	-		
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by structure removal/	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.		
	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	replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.			
	Hydraulic & Geomorphic Modifications										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, and juvenile life-history stages. May affect adult spawning productivity.		
	Altered flow regime	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.				

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation			-	-			-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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 egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 causefine sediment embeddedness may lead todirect mortality and decreased survival of eggsand larvae.Juveniles and adults:Responses varydepending on stressor magnitude.Unavoidable extreme turbidity may causephysical injury and/or physiological effects(e.g., gill trauma, altered osmoregulation,blood chemistry changes).Moderate to highturbidity may cause behavioral alteration (e.g.,avoidance responses) leading to increasedterritoriality, reduced foraging opportunity,increased predation exposure, and alteredmigration behavior.Adults:Reduction in suitable spawninghabitat (due to substrate embeddedness) andreduced 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential for increased passage to adversely affect eutrophication. Address anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Table A-10 (continued).HPA HCP Fish Pas

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure	1	1			Resulting Effects of the
аснуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more	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 stream bank and shoreline 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 larvae; Juveniles; Adults	effects of this worst-case scenario are similar to those described for roughened channels.	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 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		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		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and larvae, juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Aquatic Vegetation Modifications							_	_
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish. Table A-10 (continued).

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications				-				
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		and stability, leading to decreased incubation success and larval survival.proj desi desiJuveniles: 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.	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 substrate composition		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-	-	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-	In a st Mashanimu (Exj	posure	ŕ			Domiting Efforts of the	
асиуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Failure to capture and relocate fish may leadto mortality from stranding.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.
Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 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 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 egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and larval mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 causefine sediment embeddedness may lead todirect mortality and decreased survival of eggsand larvae.Juveniles and adults:Responses varydepending on stressor magnitude.Unavoidable extreme turbidity may causephysical injury and/or physiological effects(e.g., gill trauma, altered osmoregulation,blood chemistry changes).Moderate to highturbidity may cause behavioral alteration (e.g.,avoidance responses) leading to increasedterritoriality, reduced foraging opportunity,increased predation exposure, and alteredmigration behavior.Adults:Reduction in suitable spawninghabitat (due to substrate embeddedness) andreduced 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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-		Exposure			1	1	_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 larvae; Juveniles; Adults	Eggs/larvae:Decreased incubation success due to egg sedimentation as described for related stressor responses under Water Quality Modifications.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 Modifications.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modifications.	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 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	<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 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	<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.	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 exchange	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. <u>Adults</u> : 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, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish. Table A-10 (continued).

Sub-			Exj	oosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		•	-	-	-		-	-
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Hydraulic & Geomorphic Modifications								
	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, 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		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	 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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-		-			-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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 life-history stages: See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish are notcaptured and relocated successfully. <u>Juveniles</u> :Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure. <u>Adults</u> :Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	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 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 egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed 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 eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure									
activity Type	Impact Mechanism/ Submechanism	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)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and larval survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, mortality andincreased 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, and adult spawning fitness and productivity.				
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.				
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.				
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.				
	Water Quality Modifications												
		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:Decreased survival 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.				

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Table A-10 (continued). HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Ţ			Ex	posure					
ty	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to smothering of eggs by fine sediments as described for related stressor responses under Water Quality Modifications. 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 Modifications. <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 Modifications.	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 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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish. Table A-10 (continued).

Sub-			Ex	posure	_							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Aquatic Vegetation Modifications	•				-		-	-			
	Altered autochthonous 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.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.			
	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.	during project construction.	May affect juvenile survival, growth, and fitness.			
	Hydraulic & Geomorphic Modifications											
	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	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, 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		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	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	oject est			
	Altered substrate composition]	Year round	Permanent	Continuous							
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous							

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	•	-	-	-	-	-	-	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Iuveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
							resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.		
Trap a	and Haul Operation	S							
	Operational Activities			_	_			-	
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Establish a capture and handling protocol appropriate for whitefish.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and Jarvae; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.
	Ecosystem Fragmentation			-		_		-	
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Pygmy Whitefish.

Sub-	rity Impact Mechanism/ e Submechanism		Exj	posure			-		
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	Juveniles; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.
n/a = Not a	pplicable, no exposure to the su	bmechanism and related stressors will occur an	d there are therefore no	effects.					

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culve	rts (removed/replac	ced/retrofitted for fish passa	age)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <u>All exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Table A-11. HPA HCP Fish Passage Structures Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ex	posure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	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.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
							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.		
							<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.		
		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 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 egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability,	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
							increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration increased stress		
							decreased spawning fitness.		
		Stream bed disturbance, increased turbidity (associated with site rewatering) During project construction and maintenance activities	During project construction and maintenance	d 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.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning
			activities				<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.		productivity.
							<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Olympic Mudminnow.

d). HPA HCP Fish Passage Structures Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and larval survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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> : This species has a wide temperature tolerance range. May result in behavioral alteration.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult behavior.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by impoundment draining), dependent on contributing mechanism of impact	Intermittent to intermediate-term (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral alteration resulting in increased predation exposure (mudminnows are tolerant of wide variations in DO levels due to the ability to absorb atmospheric oxygen).	Avoid large sediment pulses or dewatering of culvert induced impoundments where practicable.	May affect egg and larval survival. May affect juvenile and adult behavior.

Sub-			Ex	posure						
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
		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. <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 larvae. May affect juvenile growth and fitness and adult productivity and spawning success.	
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.	
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.	
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.	

HPA HCP Fish Passage Structures Exposure and Response Matrix for Olympic Mudminnow.

Table A-11	(continued).
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HPA HCP Fish Passage Structures Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications	•	•	<u>.</u>		-	-	-	-
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, the extent of riparian modification resulting from structure removal/ replacement/ retrofit for fish passage purposes is expected to be limited in comparison to initial installation. Therefore, the additional	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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 larvae; Juveniles; Adults	incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile and adult survival, growth, and fitness. May affect spawning productivity, abundance and distribution.
	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	However, the extent of aquatic vegetation modification caused by structure removal/ replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications			·	<u>.</u>	<u>.</u>	•	<u>.</u>	`
	Altered channel geometry	Change in habitat structure and habitat	Year-round	Permanent	Continuous	Eggs and larvae;	All exposed life history stages: Altered	Carefully evaluate project siting and	May affect survival, growth, and
	Altered flow regime	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	Juveniles; Adults	channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. Mudminnow are dependent on habitats with low or zero flow velocity, loose silt substrate, and abundant aquatic vegetation for survival. Any alterations in hydraulic 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	fitness at all life history stages, spawning productivity. May affect distribution and abundance.
	Altered substrate composition and stability		Year round	Permanent	Continuous		geomorphic conditions that affect flow and substrate characteristics are likely to affect	extent practicable.	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		habitat suitability for this species. This in turn is likely to affect survival, growth, and fitness at all life history stages, spawning productivity, and distribution and abundance.		
	Ecosystem Fragmentation								
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows do not exhibit migratory behavior.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable foraging, resting, and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for
	Flow bypass, fish handling, and channel rewatering	n/a	n/a	n/a	n/a	n/a	n/a	n/a	fish ladder/fishway development. Exposure to these submechanisms and
	Construction/maintenance dredging	n/a	n/a	n/a	n/a	n/a	n/a	n/a	related stressors is unlikely to occur.
	Water Quality Modifications								
		n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for fish ladder/fishway development. Exposure to water quality related stressors is unlikely to occur.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for fish ladder/fishway development. Exposure to these submechanisms and related stressors is unlikely to occur.
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Aquatic Vegetation Modifications								
	Altered autochthonous production	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for fish ladder/fishway
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	development. Exposure to these submechanisms and related stressors is unlikely to occur.

Sub-		echanism/				,			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications				-				
	Altered channel geometry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for fish ladder/fishway development.
	Altered flow regime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Exposure to these submechanisms and
	Altered substrate composition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	related stressors is unlikely to occur.
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Ecosystem Fragmentation								
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows are non-
	Modified upstream transport of allochthonous nutrients	n/a	n/a	n/a	n/a	n/a	n/a	n/a	low gradient habitats unsuitable for fish ladder/fishway development.
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for
	Flow bypass, fish handling, and channel rewatering	n/a	n/a	n/a	n/a	n/a	n/a	n/a	roughened channel development. Exposure to these submechanisms and related stressors is unlikely to occur
	Construction/maintenance dredging	n/a	n/a	n/a	n/a	n/a	n/a	n/a	related sitessors is uninkely to occur.
	Water Quality Modifications								
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for roughened channel development. Exposure to water quality related stressors is unlikely to occur.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a	n/a	n/a	roughened channel development. Exposure to these submechanisms and related stressors is unlikely to occur
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	related successors is unlikely to occur.
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Sub-			Exp	osure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications					-			
	Altered autochthonous production	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	roughened channel development. Exposure to these submechanisms and related stressors is unlikely to occur.
	Hydraulic & Geomorphic Modifications					1			
	Altered channel geometry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in
	Altered flow regime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	low gradient habitats unsuitable for
	Altered substrate composition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Exposure to these submechanisms and related stressors is unlikely to occur.
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Ecosystem Fragmentation								
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows are non-
	Modified upstream transport of allochthonous nutrients	n/a	n/a	n/a	n/a	n/a	n/a	n/a	migratory species occurring only in low gradient habitats unsuitable for roughened channel development.
	Modified downstream transport of wood, sediment and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for
	Flow bypass, fish handling, and channel rewatering	n/a	n/a	n/a	n/a	n/a	n/a	n/a	fish passage weir development. Exposure to these submechanisms and
	Construction/maintenance dredging	n/a	n/a	n/a	n/a	n/a	n/a	n/a	related successors is unlikely to occur.
	Water Quality Modifications								
		n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for fish passage weir development. Exposure to water quality related stressors is unlikely to occur.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications			-	-	-	-	-	
	Altered shading, solar input and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for fish passage weir development.
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Exposure to these submechanisms and related stressors is unlikely to occur.
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Aquatic Vegetation Modifications								
	Altered autochthonous production	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in low gradient habitats unsuitable for
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	fish passage weir development. Exposure to these submechanisms and related stressors is unlikely to occur. May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications				· · · · · · · · · · · · · · · · · · ·				
	Altered channel geometry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows occur only in
	Altered flow regime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	low gradient habitats unsuitable for
	Altered substrate composition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Exposure to these submechanisms and related stressors is unlikely to occur.
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Ecosystem Fragmentation								
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows are non-
	Modified upstream transport of allochthonous nutrients	n/a	n/a	n/a	n/a	n/a	n/a	n/a	migratory species occurring only in low gradient habitats unsuitable for fish passage weir development.
	Modified downstream transport of wood, sediment and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Trap a	and Haul Operation	IS							
	Operational Activities								
	Fish capture, handling, and release	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows do not occur in habitats suitable for trap and haul
	Accidental introduction of toxic substances	n/a	n/a	n/a	n/a	n/a	n/a	n/a	operations and do not exhibit migratory behavior.
	Ecosystem Fragmentation								
	Alteration of migratory corridor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Olympic mudminnows do not occur in habitats suitable for trap and haul
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	operations and do not exhibit migratory behavior.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culve	rts (removed/replac	ed/retrofitted for fish pass	age)	·					
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <u>All exposed 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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. Cyprinids such as dace, chub, and suckers are hearing specialist species which have been demonstrated to be sensitive to auditory masking and hearing threshold effects.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	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. <u>Juveniles</u> :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 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 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 egg scour and/orsedimentation, resulting in decreasedincubation 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 larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed 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 eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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 Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

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Sub-			Exposure						
activity Type	Impact Mechanism/ Submechanism	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 or dam removal)	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 eggincubation success and larval survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	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, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenile</mark> s; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications							-	-
		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:Decreased survival 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.

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Sub-			Ex	posure	1	1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), 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. <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 where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.
		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. <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 larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

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Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, the extent of riparian modification resulting from structure removal/ replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline 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 larvae; Juveniles; Adults	similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

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Sub-			posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		<u>.</u>			<u>.</u>		-	-
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. However, the extent of aquatic vegetation modification caused by structure removal/	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter juvenile behavior; may affect juvenile growth and fitness for intermediate-term period.
	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	replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, and juvenile life-history stages. May affect adult spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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	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 substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		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		

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Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	·	•	-		-		<u>.</u>	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Iuveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream	Decreased food web productivity induced	Year-round	Permanent	Continuous	Eggs and larvae;	and diversity. <u>All exposed life-history stages</u> : Reduced warely of allochthemaneus putrients can have	Follow recommendations for avoiding	May affect survival, growth, and
	nutrients	allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses				Adults	a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	creets on rish passage.	affect adult spawning fitness and productivity through long-term effects on habitat complexity.

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Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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. Cyprinids such as dace, chub, and suckers are hearing specialist species which have been demonstrated to be sensitive to auditory masking and hearing threshold effects.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	All expose life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <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 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 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 egg scour and/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<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.

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Sub-	Sub- activity Impact Mechanism/		Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential for increased passage to adversely affect eutrophication. Address anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Riparian Vegetation Modifications		-	-	-	-				
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances.	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 stream bank and shoreline 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 larvae; Juveniles; Adults	However, in cases where fish fadders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 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		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	J <mark>uveniles;</mark> Adults		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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults		Avoid disturbance of vegetation along stream.	May affect survival of eggs and larvae, juvenile survival, growth, and fitness, and adult survival and spawning productivity.	
	Aquatic Vegetation Modifications									
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.	
	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		during project construction.		

Sub-		Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Hydraulic & Geomorphic Modifications									
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, and juvenile life-history stages. May affect spawning productivity.	
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	- Aduits	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	duitscomposition can and stability, leading to decreased incubation success and larval survival.impact increased selection designs that minimize effect channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This mayimpact increased reased reased incubation designs that minimize effect substrate composition, and groundwater exchange to the extent practicable.	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival			
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.			

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	<u>.</u>	<u>.</u>	•	<u>.</u>	<u>.</u>	<u>.</u>	<u>.</u>
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	And diversity.All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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. Cyprinids such as dace, chub, and suckers are hearing specialist species which have been demonstrated to be sensitive to auditory masking and hearing threshold effects.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	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 stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Failure to capture and relocate fish may leadto mortality from stranding.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub- activity Impact Mechanism/		Ex	posure						
activity Type	Impact Mechanism/ Submechanism	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 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 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 egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : 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.
		Stream bed 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 eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	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	<u>Juveniles</u> : 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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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	<u>Juveniles</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, mortality and increased predation risk. <u>Adults</u> : 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.

Table A-12 (continued).	HPA HCP Fish Passage	e Structures Exposure	and Response Matrix fo	or Leopard Dace. U	Jmatilla Dace. Lake	Chub. Margi
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Sub-			Ex	posure	1	1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and larval mortality or injury is highly likely if exposure occurs. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modifications.
	Water Quality Modifications								
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration 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	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.

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gined Sculpin, and Mountain Sucker.

Table A-12 (continued).	HPA HCP Fish Passage	Structures Exposure	and Response Matrix	for Leopard Dace.	. Umatilla Dace. Lak	e Chub. Margi
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Sub-			Ех	kposure	1	1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 causefine sediment embeddedness may lead todirect mortality and decreased survival of eggsand larvae.Juveniles and adults:Responses varydepending on stressor magnitude.Unavoidable extreme turbidity may causephysical injury and/or physiological effects(e.g., gill trauma, altered osmoregulation,blood chemistry changes).Moderate to highturbidity may cause behavioral alteration (e.g.,avoidance responses) leading to increasedterritoriality, reduced foraging opportunity,increased predation exposure, and alteredmigration behavior.Adults:Reduction in suitable spawninghabitat (due to substrate embeddedness) andreduced 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 cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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: Decreased survival 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. <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.

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gined Sculpin, and Mountain Sucker.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to egg sedimentation as described for related stressor responses under Water Quality Modifications. 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 Modifications. 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 Modifications.	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 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	<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 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	<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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Decreased incubationsuccess.Juveniles and adults:Decreased availabilityof thermal refuge habitat, limiting juvenilesurvival, growth, and fitness.May limit adultsurvival and spawning productivity.Adults:Decrease in suitable spawninghabitat, increased competition, decreasedspawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and larvae, juvenile survival, growth, and fitness, and adult survival and spawning productivity.

Sub-			Exj	posure	.				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications			-	-		-	-	-
	Altered autochthonous 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.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry 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 Year-round (with stressor exposure	Permanent Permanent	Continuous Seasonal	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.	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	May affect survival at egg, larval, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate	_	occurring during high-flow events, fall through spring)	Permanant	Continuous		<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	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	composition			Termanent	Continuous		competition for suitable habitats, leading to decreased growth, fitness, and survival.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-	-	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <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 decreased 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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. Cyprinids such as dace, chub, and suckers are hearing specialist species which have been demonstrated to be sensitive to auditory masking and hearing threshold effects.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish are not 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 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	<u>Eggs and larvae, 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 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 egg scour and/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed 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. <u>Adults</u> : 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 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	<u>Juveniles</u> : 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.

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

			Ex	posure				
ty	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Li gr es an
		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, mortality and increased predation risk. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity, foraging success, mortality.	Li gr es Pe al ha
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Av cu sh
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modifications.	Li su gr pr
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	A ¹ ba
	Water Quality Modifications							
		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:Decreased survival due towinter ice formation and scour.Juveniles:Altered growth and survival causedby temperatures outside optimal growth rangeand alteration of food web patterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration delays caused by thermal barriers.	Av rip apj the

Minimization Measures	Resulting Effects of the Submechanism
mit area of dewatering to the eatest extent practicable. Follow tablished protocols for dewatering d rewatering.	See effects for related stressors under Water Quality Modifications.
mit area of dewatering to the eatest extent practicable. Follow tablished protocols for dewatering. rform slow dewatering activities to ow for movement into suitable bitats.	May effect growth and fitness at juvenile life-history stage, mortality at all life-history stages, and adult spawning fitness and productivity.
void fill or, if unavoidable, restore rrently filled or degraded shallow oreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
mit dredging-related disturbance of bmerged aquatic vegetation to the eatest extent practicable through oject siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
void turbidity effects above ckground levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-12 (continued).	HPA HCP Fish Passage Structu	ires Exposure and Response	Matrix for Leopard Dace, Un	atilla Dace, Lake Chub, Margi
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), 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.	Avoid sediment pulses. Limit nutrient inputs.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		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. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
		Altered nutrient cycling	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.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

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ined Sculpin, and Mountain Sucker.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications			-	-				
	Altered shading, solar input and ambient air temperature	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:Decreased survival 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. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to smothering of eggs by fine sediments as described for related stressor responses under Water Quality Modifications. 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 Modifications. <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 Modifications.	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 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	<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 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	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.	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 exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		•	-	-	-		-	-
	Altered autochthonous 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.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
	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.	during project construction.	May affect juvenile survival, growth, and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Addis	and stability, leading to decreased incubation success and larval survival.project. Encourage selection of project designs that minimize effects on 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 toproject. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.		
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	·	•	-		-		<u>.</u>	
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Iuveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream	Decreased food web productivity induced	Year-round	Permanent	Continuous	Eggs and larvae;	and diversity. <u>All exposed life-history stages</u> : Reduced warely of allochthemaneus putrients can have	Follow recommendations for avoiding	May affect survival, growth, and
	nutrients	allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses				Adults	a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.		affect adult spawning fitness and productivity through long-term effects on habitat complexity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Trap a	nd Haul Operation	IS							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	 Dace, chub, and sculpin are not expected to be the subject of routine trap and haul operations, however incidental exposure to trap and haul operations may occur. The likelihood of stressor exposure is considered to be discountable however. <u>Mountain sucker:</u> <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. <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. 	Establish an appropriate capture and handling protocol for mountain sucker.	Dace, chub, and sculpin: The potential effects of this sumbechanism are considered discountable. <u>Mountain sucker</u> : May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and larvae; Juveniles; Adults	Dace, chub, and sculpin are not expected to be the subject of trap and haul operations, however some potential for exposure to infrequent short-term water quality effects could occur. Should exposure occur, these stressors may impose short-term effects on survival, growth, and fitness. <u>All exposed life history stages (mountain sucker only)</u> : Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	Dace, chub, and sculpin: May affect survival, growth, and fitness across all life history stages. <u>Sucker</u> : May cause direct injury or mortality, may affect survival, growth and fitness.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	<u>All exposed life-history stages (mountain</u> <u>sucker only)</u> : Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	Dace, chub, and sculpin: No effect. <u>Mountain sucker</u> : May affect survival, growth, and fitness at juvenile life- history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	J <mark>uveniles;</mark> Adults	All exposed life-history stages (mountain sucker only): Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-		Exposure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
Culve	rts (removed/replac	ed/retrofitted for fish passag	e)		·					
	Construction and Maintenance Activities									
	Equipment operation and materials placement	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 amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : 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.	Effects of underwater noise on lampreys are unknown.	
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Transforming adults; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.	
		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	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	Effects of underwater noise on lampreys are unknown.	
		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 amocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.	
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.	
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Mortality, injury, orstress from capture, handling, and relocation.Egg and amocoetes relocation is impractical,likely leading to mortality.Adults and transforming adults:Mortality,injury, or stress from capture, handling, andrelocation.Risk of mortality from stranding iffish cannot be captured and relocatedsuccessfully.Adults:Delayed migration resulting in	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of transforming adults and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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 amocoetes; Transforming adults	Eggs and amocoetes, 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 cause direct mortality or injury at transforming adult 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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Potential egg 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, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and amocoetes life-history stages; may affect transforming adult growth and fitness; may affect adult spawning productivity
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Potential decreased eggincubation success and amocoetes survivaldue to turbidity exposure and substratedisturbance.Transforming adults:Stress and behavioralmodifications by rearing transforming adultsexposed to sediment pulses, migration delay,and increased predation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at transforming adult 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)	n/a	n/a	n/a	Lamprey are not dependent on invertebrates for prey. Therefore this stressor will have no effect.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Potential decreased eggincubation success and amocoetes survivaldue to water loss and stranding.Transforming adults:Barrier to migration,loss of habitat accessibility, stranding,migration delay, increased predation risk.Stranding may lead to direct mortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity.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 effect growth and fitness at transforming adult life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.

Sub-			Ex	kposure	1	1			
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Transforming adults; Adults	Transforming adults and adults: See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Direct injury or mortality from dredging entrainment. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury of eggs and amocoetes. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications					·			
		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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Decreased survival 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 rearing. May affect adult survival and spawning productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Transforming adults and adults</u> : behavioral avoidance of habitats affected by acute low DO events, increasing stress, predation exposure, and competition for suitable habitats. May affect transforming adult survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction where practicable.	May affect transforming adult survival, growth, and fitness as well as adult survival and spawning productivity.
		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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Turbidity sufficient to cause burial may lead to decreased survival of eggs and amocoetes. <u>Transforming adults 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, 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 amocoetes. May affect transforming adult growth and fitness and adult productivity and spawning success.

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of transforming adults and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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 amocoetes; Transforming adults; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, the extent of riparian modification resulting from structure removal/ replacement retrofitting for fish passage purposes is expected to be limited in comparison to initial installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness during transforming adult rearing for intermediate-term period.
	Altered stream bank and shoreline 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 amocoetes; Transforming adults; Adults	similarly minor across all submechanisms.		
	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	Amocoetes			
	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, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Amocoetes; Transforming adults; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Adults			

Sub-			Ex	posure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	•					•	-	-
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Amocoetes	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of transforming adults. However, the extent of aquatic vegetation modification caused by structure removal/	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May alter transforming adult behavior; may affect transforming adult growth and fitness for intermediate-term period.
	Altered habitat complexity	Altered food web productivity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Amocoetes	replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming	Eggs and amocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, amocoetes, and transforming adult life-history stages. May affect adult spawning
	and reduced spawning and rearing habitat Altered flow regime	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	adults; Adults	and stability, leading to decreased incubation success and amocoetes survival.project. Encourage select designs that minimize ef channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat suitability during migration, increasingproject. Encourage select designs that minimize ef channel geometry, flow substrate composition, a groundwater exchange to extent practicable.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	test productivity.	
	Altered substrate composition and stability		Year round (with	Permanent	Continuous	_	predation exposure and stress. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and		
	surface water exchange		stressor exposure occurring during egg incubation and transforming adult rearing)				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.		

Table A-13 (continued)	HPA HCP Fish Passage St	ructures Exposure and Response	Matrix for Pacific Lamnrey River Lamnrey
Table A-15 (continueu).	III A IICI FISH I assage St	i uctures Exposure and Response.	Matrix for Facilic Lamprey, River Lamprey,

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-			
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Transforming adults; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Transforming adults</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Transforming adults may be denied the ability to migrate downstream in certain circumstances. Transforming adults may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at transforming adult life- history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream	Decreased food web productivity induced	Year-round	Permanent	Continuous	Amocoetes;	and diversity. All exposed life-history stages: Reduced	Follow recommendations for avoiding	May affect survival, growth, and
	transport of allochthonous nutrients	by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses					supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	effects on fish passage.	fitness of amocoetes and transforming adults. May affect adult spawning fitness and productivity through long- term effects on habitat complexity.

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, and Brook Lamprey.

Sub-			Ex	posure	1	7			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Transforming adults; Adults	Adults and transforming adults: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect transforming adult survival, growth, and fitness. May affect adult survival and spawning productivity.
Fish L	adders/Fishways								
	Construction and Maintenance Activities								
	ty Impact Mechanism Submechanism memport of wood, sedmeen and organic material Decreased habitati complexity and food web productivity When Duration Frequency Life-history from address Address t Decreased habitati complexity and food web productivity Year round Permanent Continuous Transforming Address Address t Lateletrs/Fishways Construction and Maintenance Activitie Internance Activitie Egspanet Egspanet Egspanet Fermionant and organic material project construction and maintenance Internance Activitie Egspanet Egspanet Egspanet Fermionant and organic material project construction and maintenance Internance activities Temporary (auditory maintenance) Internance in address address and maintenance Egspanet address address and coreases Address and coreases Fermionant and maintenance Visual and physical disturbance resulting in increased seliments During project construction and maintenance activities Temporary maintenance activities Internanual to decadal (during project construction and maintenance) Transforming address address Address address address address Address address address address Address address address address Address address address address Address address address	<u>All life-history stages</u> : 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.	Effects of underwater noise on lampreys are unknown.					
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Transforming adults; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	Effects of underwater noise on lampreys are unknown.
		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 amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 amocoetes; Transforming adults; Adults	Eggs and amocoetes:Mortality, injury, orstress from capture, handling, and relocation.Egg relocation is impractical, likely leading tomortality.Adults and transforming adults:Mortality, injury, or stress from capture, handling, andrelocation.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of transforming adults 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 amocoetes; Transforming adults	Eggs and amocoetes, 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 cause direct mortality or injury at transforming adult 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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Potential egg scour and/or sedimentation, resulting in decreased incubation success. <u>Transforming adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and amocoetes life-history stages; may affect transforming adult growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	<u>Transforming adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect transforming adult growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Potential decreased eggincubation success and amocoetes survivaldue to turbidity exposure and substratedisturbance.Transforming adults:Stress and behavioralmodifications by rearing transforming adultsexposed to sediment pulses, migration delay,and increased predation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at transforming adult 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)	n/a	n/a	n/a	Lamprey are not dependent on invertebrates for prey. Therefore this stressor will have no effect.

Table A-13 (continued).	HPA HCP Fish Passage	Structures Exposure and	Response Matrix for Pac	ific Lamprey, River Lamprey,
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Sub-	Impact Mechanism/	posure					Deculting Effects of the		
activity Type	Impact Mechanism/ Submechanism	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 amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Direct injury or mortality from dredging entrainment. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect transforming adult growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Transforming adults; Adults	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 rearing. May affect adult survival and spawning productivity.
		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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of Eggs and amocoetes. <u>Transforming adults 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, 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 amocoetes. May affect transforming adult growth and fitness and adult productivity and spawning success.

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Sub-			Ex	posure	Ĩ	1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect transforming adult survival and fitness. May affect adult survival and spawning productivity.
		Altered nutrient cycling	During and following discharge events	Long-term to permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen concentrations.	Evaluate potential for increased passage to adversely affect eutrophication. Address anthropogenic sources of nutrient pollution to compensate.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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 amocoetes; Transforming adults; Adults	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels.	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 rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 amocoetes; Transforming adults; Adults		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 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	Amocoetes		Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect transforming adult 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, 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		Encourage project designs that limit permanent alteration of habitat features.	May affect transforming adult growth and survival, as well as spawning success and overall population productivity.

ub-			Ex	posure					
ctivity ype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Adults		Avoid disturbance of vegetation along stream.	May affect survival of Eggs and amocoetes, transforming adult survival, growth, and fitness, and adult survival and spawning productivity.
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Amocoetes	The degree to which fish ladders/fishways affect aquatic vegetation conditions in riverine environments is anticipated to be limited. The magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	Altered habitat complexity	Reduced food web productivity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Amocoetes; Transforming adults; Adults		during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming	Eggs and amocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, amocoetes, and transforming adult life-history stages. May affect spawning
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	adults; Adults	 and stability, leading to decreased incubation success and amocoetes survival. <u>Transforming adults</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat suitability during migration, increasing 	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	productivity.
	Altered substrate composition		Year round	Permanent	Continuous		Adults: Changes in channel morphology may		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and transforming adult rearing)	Permanent	Continuous		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.		

Table A-13 (continued).	HPA HCP Fish Passage S	Structures Exposure and	l Response Matrix for F	Pacific Lamprey, River Lamprey	7.
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-	-	-	-	-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Transforming adults; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Transforming adults</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Transforming adults may be denied the ability to migrate downstream in certain circumstances. Transforming adults may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival, growth, and fitness at transforming adult life- history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Amocoetes	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of amocoetes and transforming adults. May affect adult spawning fitness and productivity through long- term effects on habitat complexity.

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Table A-13 (continued).	HPA HCP Fish Passage	Structures Exposure and	l Response Matrix for l	Pacific Lamprey, River	Lamprey,
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : 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.	Effects of underwater noise on lampreys are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Transforming adults; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	Effects of underwater noise on lampreys are unknown.
	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 amocoetes; Transforming adults; Adults	Eggs and amocoetes:Mortality, injury, orstress from capture, handling, and relocation.Egg relocation is impractical, likely leading tomortality.Adults and transforming adults:Mortality, or stress from capture, handling, andrelocation.Failure to capture and relocate fishmay lead to mortality from stranding.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of transforming adults 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 amocoetes; Transforming adults	Eggs and amocoetes, 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 cause direct mortality or injury at transforming adult 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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Potential egg scour and/or sedimentation, resulting in decreased incubation success. <u>Transforming adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and amocoetes life-history stages; may affect transforming adult growth and fitness; may affect adult spawning productivity.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	Transforming adults:Altered habitatsuitability, increased stress, increasedcompetition, 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 transforming adult growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Potential decreased eggincubation success and amocoetes survivaldue to turbidity exposure, burial, and substratedisturbance.Transforming adults:Stress and behavioralmodifications by rearing transforming adultsexposed to sediment pulses, migration delay,and increased predation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at transforming adult 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)	n/a	n/a	n/a	Lamprey are not dependent on invertebrates for prey. Therefore this stressor will have no effect.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		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, mortality and increasedpredation risk.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,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/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.

Table A-13 (continued).	HPA HCP Fish Passage Structure	es Exposure and Response Matr	ix for Pacific Lamprey, River Lamprey,
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Direct injury or mortality from dredging entrainment. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	Egg and amocoetes mortality or injury is highly likely if exposure occurs. May affect transforming adult growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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 amocoetes; Transforming adults; Adults	Eggs and amocoetes:Decreased survival dueto winter ice formation and scour.Transforming adults:Altered growth andsurvival caused by temperatures outsideoptimal growth range and alteration of foodweb patterns.Adults and transforming adults:Directmortality caused by exposure to temperaturesin excess of tolerance thresholds.Adults:Decreased spawning fitness due tomigration 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 rearing. May affect adult survival and spawning productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses. Limit nutrient inputs.	May affect transforming adult survival, growth, and fitness as well as adult survival and spawning productivity.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of Eggs and amocoetes. <u>Transforming adults 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, 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 amocoetes. May affect transforming adult growth and fitness and adult productivity and spawning success.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	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 amocoetes; Transforming adults; Adults	Eggs and amocoetes:Decreased survival dueto winter ice formation and scour.Transforming adults:Altered growth andsurvival caused by temperatures outsideoptimal growth range and alteration of foodweb patterns.Adults and transforming adults:Directmortality caused by exposure to temperaturesin excess of tolerance thresholds.Adults:Decreased spawning fitness due tomigration 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 rearing. May affect adult survival and spawning productivity.
Sub-			Ex	posure					
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activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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 amocoetes; Transforming adults; Adults	Eggs/amocoetes:Decreased incubation and rearing success due to egg sedimentation as described for related stressor responses under Water Quality Modifications.Transforming adults:Decreased refuge habitat availability, leading to increased competition and resulting effects on survival. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modifications.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 Modifications.	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 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	Amocoetes	<u>Amocoetes:</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 ammocoete 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, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Amocoetes; Transforming adults; Adults	Amocoetes:Decreased availability of suitablerearing habitat, reduced food webproductivity, with resulting effects onsurvival, growth, and fitness.Transforming adults:Decreased refugehabitat availability with resulting effects onsurvival.Adults:Increased mortality; decreased fitnessand spawning success due to decreasedavailability of suitable migratory andspawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect transforming adult growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Decreased incubationand rearing success.Transforming adults and adults:Decreasedavailability of thermal refuge habitat, limitingtransforming adult survival, growth, andfitness.May limit adult survival andspawning productivity.Adults:Decrease in suitable spawninghabitat, increased competition, decreasedspawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of Eggs and amocoetes, transforming adult survival, growth, and fitness, and adult survival and spawning productivity.

Sub-			Exp	posure	,		_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications	•	-	-	-	-		-	-
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Amocoetes	<u>Amocoetes</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect ammocoete growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Amocoetes;	<u>Amocoetes:</u> Reduced availability of suitable rearing habitats, leading to effects on survival, growth and fitness.	during project construction.	May affect ammocoete survival, growth and fitness.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming	Eggs and amocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, amocoetes, and transforming adult life-history stages. May affect spawning
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	adults; Adults	and stability, leading to decreased incubation success and amocoetes survival. <u>Transforming adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat suitability during migration, increasing	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	productivity.
	Altered substrate composition		Year round	Permanent	Continuous	-	Adults: Changes in channel morphology may		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and transforming adult rearing)	Permanent	Continuous		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.		

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Table A-13 (continued).	HPA HCP Fish Passage	Structures Exposure a	and Response Matrix for	Pacific Lamprey, River Lamprey,

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-		-		-	-
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Transforming adults; Adults	Roughened channels will generally improve the condition of this submechanism. However, designs that are poorly conceived may create unintentional passage barriers over time. Should this occur, the following effects may be realized. <u>Transforming adults</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Transforming adults may be denied the ability to migrate downstream in certain circumstances. Transforming adults may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review roughened channel designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at transforming adult life- history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for fish passage listed above.	May affect survival, growth, and fitness of amocoetes and transforming adults. May affect adult spawning fitness and productivity through long- term effects on habitat complexity.

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Sub-	Trans (Markanian /	_	Exj	oosure	I	I			
асиуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Transforming adults; Adults	Adults and transforming adults: Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable resting and spawning sites due to effects on habitat complexity may affect survival and spawning productivity.	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable. Where appropriate, channels may be designed to capture large wood, contributing to habitat complexity.	May affect transforming adult survival, growth, and fitness. May affect adult survival and spawning productivity.
Weirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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 amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : 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.	Effects of underwater noise on lampreys are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Transforming adults; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		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	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	Effects of underwater noise on lampreys are unknown.
		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 amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	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 amocoetes; Transforming adults; Adults	Eggs and amocoetes:Mortality, injury, orstress from capture, handling, and relocation.Egg relocation is impractical, likely leading tomortality.Adults and transforming adults:Mortality, or stress from capture, handling, andrelocation.Risk of mortality from stranding iffish are not captured and relocatedsuccessfully.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of transforming adults 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 amocoetes; Transforming adults	Eggs and amocoetes, 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 cause direct mortality or injury at transforming adult 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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Potential egg scour and/or sedimentation, resulting in decreased incubation success. <u>Transforming adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and amocoetes life-history stages; may affect transforming adult growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Potential decreased eggincubation success and amocoetes survivaldue to turbidity exposure and substratedisturbance.Transforming adults:Stress and behavioralmodifications by rearing transforming adultsexposed to sediment pulses, migration delay,and increased predation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at transforming adult 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)	n/a	n/a	n/a	Lamprey are not dependent on invertebrates for prey. Therefore this stressor will have no effect.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

1 able A-13 (continued). HPA HCP Fish Passage Structures Exposure and Response Matrix for Pacific Lamprey, Rive	er Lamprey
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes:Potential decreased eggincubation success and amocoetes survivaldue to water loss and stranding.Transforming adults:Barrier to migration,loss of habitat accessibility, stranding,migration delay, mortality and increasedpredation risk.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,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 transforming adult life-history stage, mortality at all life-history stages, and adult spawning fitness and productivity.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and amocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury. See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Direct injury or mortality from dredging entrainment. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect transforming adult growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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 amocoetes; Transforming adults; Adults	Eggs and amocoetes:Decreased survival dueto winter ice formation and scour.Transforming adults:Altered growth andsurvival caused by temperatures outsideoptimal growth range and alteration of foodweb patterns.Adults and transforming adults:Directmortality caused by exposure to temperaturesin excess of tolerance thresholds.Adults:Decreased spawning fitness due tomigration 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 rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses. Limit nutrient inputs.	May affect transforming adult survival and productivity as well as adult survival, productivity, and spawning success.
		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 amocoetes; Transforming adults; Adults	Eggs and amocoetes: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of Eggs and amocoetes. <u>Transforming adults 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, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that 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 amocoetes. May affect transforming adult growth and fitness and adult productivity and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of transforming adults and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure		1			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications			-	-	-			
	Altered shading, solar input and ambient air temperature	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 amocoetes; Transforming adults; Adults	Eggs and amocoetes:Decreased survival dueto winter ice formation and scour.Transforming adults:Altered growth andsurvival caused by temperatures outsideoptimal growth range and alteration of foodweb patterns.Adults and transforming adults:Directmortality caused by exposure to temperaturesin excess of tolerance thresholds.Adults:Decreased spawning fitness due tomigration 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. May affect survival, growth, and fitness during transforming adult rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline 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 amocoetes; Transforming adults; Adults	Eggs/amocoetes: Decreased incubation success due to smothering of eggs by fine sediments as described for related stressor responses under Water Quality Modifications. <u>Transforming adults:</u> Decreased refuge habitat availability leading to increased stress and predation exposure. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modifications. <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 Modifications.	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 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	Amocoetes	<u>Amocoetes:</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 ammocoete 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, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Amocoetes; Adults	<u>Amocoetes:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Transforming adults and adults:</u> Decreased survival and spawning fitness due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of habitat features.	May affect ammocoete growth and fitness. May affect transforming adult growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Adults	Eggs and amocoetes: Decreased incubation and rearing success. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of Eggs and amocoetes, as well as adult spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications				-	-			
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Amocoetes	<u>Amocoetes</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect ammocoete growth and fitness.
	Altered habitat complexity	Reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults and adults: Decreased migratory refuge habitat availability leading to increased stress and predation exposure resulting in decreased survival, growth and fitness, and adult spawning productivity.	during project construction.	May affect transforming adult and adult survival, growth, and fitness. May affect adult spawning productivity.
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming	Eggs and amocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, amocoetes, and transforming adult life-history stages. May affect spawning
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	adults; Adults	and stability, leading to decreased incubation success and amocoetes survival. <u>Transforming adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat suitability during migration, increasing	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	productivity.
	Altered substrate composition		Year round	Permanent	Continuous		predation exposure and stress. <u>Adults</u> : Changes in channel morphology may load to alteration of the migratory corridor and		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and transforming adult rearing)	Permanent	Continuous		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.		

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Table A-13 (continued).	HPA HCP Fish Passage	Structures Exposure a	and Response Matrix for	Pacific Lamprey, River Lamprey,

Sub-	Immed Mechanisms/		Ex	posure		1	-		Descriting Effects of the
Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Ecosystem Fragmentation								
	Barriers to fish passage	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Transforming adults; Adults	Structures designed to promote fish passage will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly implemented may create unintentional passage barriers. Should this occur, the following effects may be realized. <u>Transforming adults</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Transforming adults may be denied the ability to migrate downstream in certain circumstances. Transforming adults may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity	Require competent engineering of all fish passage projects. Evaluate passage requirements of all HCP species occurring or potentially occurring in the affected stream system. Review structure designs for their ability to pass desired fish species at all life-history stages using sound hydraulic engineering and geomorphic design principles.	May affect survival, growth, and fitness at transforming adult life- history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of amocoetes and transforming adults. May affect adult spawning fitness and productivity through long- term effects on habitat complexity.

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Sub-			Ex	posure	ľ	T.	-		
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Transforming adults; Adults	Adults and transforming adults:Decreasedavailability of suitable rearing habitats andundesirable effects on food web productivitymay lead to decreased survival, growth, andfitness.Adults:Decreased availability of desirableresting and spawning sites due to effects onhabitat complexity may affect survival andspawning productivity.	Design structures for transparency to transport of wood, sediment and organic debris to the greatest extent practicable	May affect transforming adult survival, growth, and fitness. May affect adult survival and spawning productivity.
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	Operational Activities		1	_	1			1	1
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Adults	<u>Adults</u> : Mortality, injury, or stress from capture, handling, and relocation. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Transforming adults; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	See recommendations under accidental releases of toxic substances under Structures.	May cause direct injury or mortality; may affect survival, growth, and fitness of transforming adults and survival and spawning productivity of adults.
	Ecosystem Fragmentation		•						
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Transforming adults; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not captured.	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at transforming adult life- history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.

Sub-		Exj	posure					
activity Impact Mechanism/ Type Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	Transforming adults; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
Culver	rts (removed/replac	ed/retrofitted for fish passag	e)								
	Construction and Maintenance Activities										
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in		
	Dewatering and fish handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Washington State suitable for culverts that could affect fish		
	Construction/maintenance dredging	n/a	n/a	n/a	n/a	n/a	n/a	n/a	exposure will occur		
	Water Quality Modifications										
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in Washington State suitable for culverts that could affect fish passage. Therefore no stressor exposure will occur		
	Riparian Vegetation Modifications										
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in Washington State suitable for		
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a	n/a	n/a	culverts that could affect fish passage. Therefore no stressor exposure will occur		
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a			

Table A-14. HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

Table A-14 (continued). HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

Sub-			Ext	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications						-		
	Altered autochthonous production	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Washington State suitable for culverts that could affect fish passage. Therefore no stressor exposure will occur
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not
	Altered flow regime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Washington State suitable for
	Altered substrate composition and stability	n/a	n/a	n/a	n/a	n/a	n/a	n/a	culverts that could affect fish passage. Therefore no stressor
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	exposure will occur
	Ecosystem Fragmentation								
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in Washington State suitable for
	Modified upstream transport of allochthonous nutrients	n/a	n/a	n/a	n/a	n/a	n/a	n/a	culverts that could affect fish passage. Therefore they will not be exposed to stressors resulting from these submechanisms and no effects will result.
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Larvae;	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Design projects to effectively pass woody debris and organic material.	May affect juvenile survival, growth, and fitness.

Sub-			Ex	kposure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor		
Fish La	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	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	 <u>All exposed life-history stages</u>: 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 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. 	Avo of NC hal pil- win bul pre- or En han wh	
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Lir in- spe	
		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</u> : Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. <u>Adults</u> : May cause avoidance behavior. Note: While these responses are possible, very little is known of the	Lit ant Ho to pre the am apj	

Short-term

During project

maintenance

activities

construction and

 Table A-14 (continued).
 HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

It o:/projly2007/07-03621-000/word processing/reports/white papers/matrices/lish passage/word files/07-03621-000 apx-a matrix14-fp-sturgeon.doc

Bank/shoreline/channel disturbance,

resulting in increased sediments

Eggs and larvae;

Juveniles;

Adults

Interannual to

on activity

frequency)

decadal (depending

effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are

All life-history stages: See responses to related stressors under Water Quality

uncertain.

Modifications.

Minimization Measures	Resulting Effects of the Submechanism
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.
Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
Little is known about the effects of anthropogenic sounds on sturgeon. However, adults are not expected to be sensitive to decreased predator awareness. Regardless, the use of BMPs to manage ambient noise level effects may be appropriate.	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.
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 Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Require a TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	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. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <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 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 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:Potential egg scour and/orsedimentation, resulting in decreasedincubation success.Larvae:Alteration of dispersal mechanismsaffecting transport to suitable habitats forrearing.Juveniles:Altered habitat suitability,increased stress, increased competition,decreased growth and fitness.Adults:Delayed migration, increased stress,decreased spawning fitness.	Conduct all activities within system specific in-water work windows. Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Alteration of dispersal mechanisms affecting transport to suitable habitats. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Conduct all activities within system specific in-water work windows. 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-14 (continued).HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

Sub-			Ex	Dosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed 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, reduced foraging opportunities, and increased predation risk. <u>Adults:</u> 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 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)	Larvae; Juveniles; Adults	Larvae and juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness. Adults: Short-term displacement to habitats with more abundant forage.	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	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	May cause direct mortality or injury See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modifications.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon. Table A-14 (continued).

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications	÷	•	-		-			-
		Altered thermal regime	Annually	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Larvae;	Fishway construction is expected to have a limited effect on riparian vegetation in most circumstances (relative to the effects of the structure being bypassed). However, larval dispersal and juvenile rearing habitat may be affected in certain circumstances. Larvae: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect larval survival, growth, and fitness.
		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. <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 larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
		Introduction of toxic substances (PAHs, metals, organic pollutants)	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon. Table A-14 (continued).

Table A-14 (continued). HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications		-	-	-				
	Altered shading, solar input, and ambient air temperature	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	The degree to which fish ladders and fishways are expected to affect riparian vegetation conditions is anticipated to be insignificant relative to the effects of the flow control structure they are associated with. Therefore, the magnitude of the resulting effects from riparian vegetation modification are expected to be insignificant in most circumstances. However, in cases where fish ladders are installed to bypass natural barriers, more	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects are expected to be insignificant and discountable in most cases.
	Altered stream bank and shoreline 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 larvae; Juveniles; Adultsextensive rip effects of this to those desc This scenaric sturgeon, wh	extensive riparian effects are possible. The effects of this worst-case scenario are similar to those described for roughened channels. This scenario is not expected to affect sturgeon, which reside in mainstem river	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects are expected to be insignificant and discountable in most cases.			
	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; Juveniles; Adults;	environments.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects are expected to be insignificant and discountable in most cases.
	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	Larvae; Juveniles; Adults		Encourage project designs that limit permanent alteration of habitat features.	Effects are expected to be insignificant and discountable in most cases.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults		Avoid disturbance of vegetation along stream.	Effects are expected to be insignificant and discountable in most cases.
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	The degree to which fish ladders/fishways I affect aquatic vegetation conditions in riverine f environments is anticipated to be limited. The a magnitude of the resulting effects from f riparian vegetation modification are expected f to be insignificant. f	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	The effects of stressor exposure resulting from this mechanism of impact are expected to be insignificant.
	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		during project construction.	

HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon. Table A-14 (continued).

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications						-	-	-
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Aduns	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.	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 substrate composition		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.		

Table A-14 (continued). HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

			Ex	posure					
ity	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	·	•			-	<u>.</u>		÷
	Barriers to fish passage	 Complete or partial barriers to upstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats. Energy exertion or injury during attempts to navigate barrier structure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent (may increase in severity over time if barrier condition is created by geomorphic changes)	Continuous	Juveniles; Adults	Fish ladders and fishways will generally improve the condition of this submechanism. However, designs that are poorly conceived or improperly maintained may create unintentional passage barriers. Should this occur, the following effects may be realized <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may also exert excess energy and incur injury attempting to navigate impassable structures. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate impassible structures may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness of larvae and juveniles. May affect adult spawning fitness and productivity through long-term effects on habitat complexity.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon. Table A-14 (continued).

Sub-			Exp	osure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in
	Flow bypass, fish handling, and channel rewatering	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Washington State suitable for roughened channel projects
	Construction/maintenance dredging	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Therefore no stressor exposure will occur as a result of these submechanisms.
	Water Quality Modifications								
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in Washington State suitable for roughened channel projects intended to improve fish passage. Therefore no water quality related stressor exposure will occur.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Washington State suitable for roughened channel projects intended to improve fish passage.
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Therefore no stressor exposure will occur as a result of these
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	submechanisms.
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table A-14 (continued). HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

Sub-			Expo	osure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Aquatic Vegetation Modifications									
	Altered autochthonous production	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in	
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a		Washington State suitable for roughened channel projects intended to improve fish passage. Therefore no stressor exposure will occur as a result of these submechanisms.	
	Hydraulic & Geomorphic Modifications									
	Altered channel geometry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not	
	Altered flow regime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	occur in riverine environments in Washington State suitable for	
	Altered substrate composition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	roughened channel projects intended to improve fish passage	
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Therefore no stressor exposure will occur as a result of these submechanisms.	
	Ecosystem Fragmentation									
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not	
	Modified upstream transport of allochthonous nutrients	n/a	n/a	n/a	n/a	n/a	n/a	n/a	occur in riverine environments in Washington State suitable for roughened channel projects intended to improve fish passage	
	Modified downstream transport of wood, sediment and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Therefore no stressor exposure will occur as a result of these submechanisms.	
Weirs										
	Construction and Maintenance Activities									
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in	
	Flow bypass, fish handling, and channel rewatering	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Washington State suitable for fish passage weirs. Therefore no	
	Construction/maintenance dredging	n/a	n/a	n/a	n/a	n/a	n/a	n/a	result of these submechanisms.	

HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon. Table A-14 (continued).

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications		-			-	-		
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in Washington State suitable for roughened channel projects intended to improve fish passage. Therefore no water quality related stressor exposure will occur.
	Riparian Vegetation Modifications								
	Altered shading, solar input and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a	n/a	n/a	washington State suitable for fish passage weirs. Therefore no stressor exposure will occur as a
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	result of these submechanisms.
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Aquatic Vegetation Modifications								
	Altered autochthonous production	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Washington State suitable for fish passage weirs. Therefore no stressor exposure will occur as a result of these submechanisms.
	Hydraulic & Geomorphic Modifications	_					-		_
	Altered channel geometry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in Washington State suitable for fish
	Altered flow regime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	passage weirs. Therefore no
	Altered substrate composition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	result of these submechanisms.
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table A-14 (continued). HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation			-	-	-			
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	White and green sturgeon do not occur in riverine environments in Washington State suitable for fish
	Modified upstream transport of allochthonous nutrients	n/a	n/a	n/a	n/a	n/a	n/a	n/a	passage weirs. Therefore no stressor exposure will occur as a result of these submechanisms.
	Modified downstream transport of wood, sediment and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Trap a	and Haul Operation	IS							
	Operational Activities								
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Established capture and handling protocols to avoid and minimize adverse impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Eggs and larvae; Juveniles; Adults	Water quality effects are similar to those described for accidental releases of toxic substances under Fish Ladders/Water Quality Modification.	Require an operational TESC plan.	May cause direct injury or mortality; may affect survival growth and fitness at all life-history stages.



Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	-		-	-		
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	Seasonal (associated with operations)	Permanent	Variable (depending on operational limitations).	Juveniles; Adults	All exposed life-history stages: Trap and haul programs may result in disruption or alteration of the migratory corridor when fish are not released in the immediate vicinity of the barrier being bypassed. This may in turn cause fish to select spawning or rearing habitats that are less suitable than the natural habitat, or increase stress and exertion by imposing increased travel distance. These stressors may affect survival, growth, and fitness. Alteration of the migratory corridor may also impose unintended selection pressures on the affected population, with adverse effects on phenotypic diversity. Trap and haul programs may impose additional selection pressures on the population if the full range of size and run- timing diversity is not cantured	Operate trap and haul programs to mimic volitional passage around barriers to the greatest extent possible (i.e., release fish immediately upstream and downstream of barriers where practicable and consistent with migratory behavior).	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult survival, fitness, and spawning productivity. May affect population diversity and spatial structure.
	Passage barriers	Unintentional passage barriers imposed by operational limitations	Seasonal to year- round (depending on nature of barrier condition)	Permanent	Variable (depending on nature of barrier condition).	Juveniles; Adults	All exposed life-history stages: Trap and haul operations can impose multiple unintentional barrier conditions when operations do not capture the full range of run timing and fish size diversity. This may in turn impose selection pressures on the affected population, reducing phenotypic diversity.	Evaluate the operational plan and require monitoring where necessary to ensure that the full range of life-history diversity is expressed.	May affect population diversity and spatial structure.

Table A-14 (continued).HPA HCP Fish Passage Structures Exposure and Response Matrix for Green Sturgeon and White Sturgeon.

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culve	rts (removed/replac	ced/retrofitted for fish passag	ge)						
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet 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 exposure to this stressor are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No specific recommendations	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		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 Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of 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)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness at juvenile life-history stage.

Sub-			Ex	posure	1	ï	_					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.			
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.			
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	n/a	n/a	n/a	These species are non-migratory and insensitive to temporary barriers to passage.			
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.			
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.			
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	J <mark>uvenil</mark> es; Adults	<u>All life-history stages</u> : Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.			
	Water Quality Modifications											
		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>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.			
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	Avoid large sediment pulses during construction where practicable.	May affect juvenile survival, growth, and fitness as well as adult survival and spawning productivity.			

Table A_{-24} (continued)	HPA HCP Fish Passage Structures Exposure and Response Matrix for Columbia River Spire Spail and Giant (
Table A-24 (continueu).	THA HOT FISH I assage Structures Exposure and Response Matrix for Columbia River Spire Shan and Giant

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. <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).	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 adult and juvenile survival, growth and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.



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Columbia River Limpet.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects on these species. However, the extent of riparian modification resulting from structure removal/replacement/retrofitting for fish passage purposes is expected to be limited in comparison to initial installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness.
	Altered stream bank and shoreline 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)	Juveniles; Adults	expected to be similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults			

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Sub-			Exj	posure				1
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modifications		-	-	-		-	
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juvenile and adult spire snail and CR limpet. However, the extent of aquatic vegetation	De im alt cor <u>Co</u> dis
	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	modification caused by removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	du
	Hydraulic & Geomorphic Modifications							
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing	Ca dea im
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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.	pro des cha sul gro ext
	Altered substrate composition and stability		Year round	Permanent	Continuous			
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous]		
	Ecosystem Fragmentation							
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Minimization Measures	Resulting Effects of the Submechanism
sign: Limit structural and poundment footprint to avoid eration of native vegetation mmunity to the extent practicable <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect growth and fitness for intermediate-term period.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival, growth and fitness.
1	n/a

Sub-								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Fol
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness	De trai org pra
Fish La	adders/Fishways							
	Construction and Maintenance Activities							
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Avv imp NC hat driv Uso red cor Eno
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Em sur and per
		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 Modifications.	Lir gre esta cor
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Rea

Minimization Measures	Resulting Effects of the Submechanism
llow recommendations for avoiding fects on fish passage.	May affect survival, growth, and fitness.
sign structures for transparency to nsport of wood, sediment, and ganic debris to the greatest extent acticable.	May affect survival, growth, and fitness.
void pile-driving noise in excess of pact thresholds established by DAA Fisheries and USFWS in bitats used by species. Limit pile ving to in-water work windows. e double-confined bubble curtain to luce sound pressure, or work within nfined or dewatered work areas. courage use of vibratory hammers d wooden pilings where practicable.	The effects of exposure to this stressor are unknown.
o specific recommendations	May affect behavior.
nploy appropriate BMPs to insulate face waters from equipment noise d vibration occurring over extended riods.	The effects of exposure to this stressor are unknown.
mit area of disturbance to the eatest extent practicable. Follow ablished protocols for erosion ntrol during construction.	See effects for related stressors under Water Quality Modifications.
quire TESC plan for all construction d maintenance activities.	See effects for related stressors under Water Quality Modifications.

Table A-24 (continued).	HPA HCP Fish Passage	Structures Exposure a	and Response Matrix for	Columbia River Spire Snail and C	Giant
		······································	· · · · · · · · · · · · · · · · · · ·	-	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of 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)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness at juvenile life-history stage.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	n/a	n/a	n/a	These species are non-migratory and insensitive to temporary barriers to passage.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>All life-history stages</u> : Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.

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Columbia River Limpet.

Sub-			Exj	posure	1	-			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modifications								-
		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>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		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	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. <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).	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 adult and juvenile survival, growth and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	J <mark>uvenil</mark> es; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects on these species. However, the extent of riparian modification resulting from structure removal/ replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	These effects are expected to be insignificant.

Sub-			Ex	posure		1			
ictivity Fype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline 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)	Juveniles; Adults	similarly minor across all submechanisms.	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 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		Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	These effects are expected to be insignificant.
	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		Encourage project designs that limit permanent alteration of habitat features.	These effects are expected to be insignificant.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults		Avoid disturbance of vegetation along stream.	These effects are expected to be insignificant.
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juvenile and adult spire snail and CR limpet. However, the extent of aquatic vegetation	Design: Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	These effects are expected to be insignificant.
	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	However, the extent of aquatic vegetation modification caused by structure removal/ replacement/ retrofitting for fish passage purposes is expected to be limited in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat	Year-round	Permanent	Continuous		Juveniles and adults: Altered channel	Carefully evaluate project siting and	May affect survival, growth, and
	Altered flow regime	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	Juveniles; Adults	geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities leading to decreased growth, fitness, and survival.	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	fitness.
	Altered substrate composition		Year round	Permanent	Continuous			extent practicable.	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

Sub-			Ex	posure		_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	<u>.</u>		•	-
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness.
Rough	nened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet 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 exposure to this stressor are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No specific recommendations	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		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	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
Sub-	Impact Mechanism/		Ex	posure	1	7			Deculting Effects of the
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activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of 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)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness at juvenile life-history stage.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	n/a	n/a	n/a	These species are non-migratory and insensitive to temporary barriers to passage.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>All life-history stages</u> : Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.

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Sub-			Exj	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Water Quality Modification											
		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>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.			
		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	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. <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).	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 adult and juvenile survival, growth and fitness.			
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	J <mark>uvenile</mark> s; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.			
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.			
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.			

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Sub-	ib- tivity Impact Machanism/										
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Riparian Vegetation Modifications										
	Altered shading, solar input, and ambient air temperature	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	Roughened channel creation may involve extensive modification of existing riparian vegetation, with attendant effects on HCP species occurring in the affected environment. Spire snails and Columbia River limpet are sensitive to turbidity and water quality impacts imposed by riparian effects. <u>Juveniles and adults</u> : See effects for related stressors under water quality modification. Effects on habitat complexity and food web	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness.		
	Altered stream bank and shoreline 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)	Juveniles; Adults	productivity may affect survival, growth, and fitness of juveniles and adults.				
	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					
	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					
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults					

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b-			Ex	posure		7			
ivity pe	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juvenile and adult spire snail and CR limpet. Juveniles and adults: Decreased refuge	Design: Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect growth, and fitness, as well as adult spawning productivity.
	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	habitat availability and foraging opportunities, leading to decreased growth and fitness.	during project construction.	
	Hydraulic & Geomorphic Modifications								
	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	<u>Juvenile and adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival, growth, fitness and spawning productivity.
	Altered flow regime		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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.	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 substrate composition		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect survival, growth, and fitness.
Weirs									
	Construction and Maintenance Activities		_		_	_		_	
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet 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 exposure to this stressor are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No specific recommendations	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		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 Modifications.	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 Modifications.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Juveniles; Adults	All expose life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of 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)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	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)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect juvenile and adult growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults:</u> Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	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)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	n/a	n/a	n/a	These species are non-migratory and insensitive to temporary barriers to passage.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>All life-history stages</u> : Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Water Quality Modifications								
		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>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A_{-24} (continued)	HPA HCP Fish Passage	Structures Exposure and	d Response Matrix for	Columbia River Spire Spail and Giant
Table A-24 (Continueu).	III A IICI TISII I assage	Su uciul es Exposure an	a Kesponse Matrix Ior	Columbia Kivel Spile Shan and Giant

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		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	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. <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).	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 adult and juvenile survival, growth and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

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Columbia River Limpet.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects on these species. However, riparian modification resulting from fish passage weirs is expected to be limited in extent. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all submechanisms.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness.
	Altered stream bank and shoreline 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)	Juveniles; Adults			
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults			
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juvenile and adult spire snail and CR limpet. However, the extent of aquatic vegetation modification caused by fish passage weirs is expected to be limited. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness for intermediate-term period.
	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	<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.

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HPA HCP Fish Passage Structures Exposure and Response Matrix for Columbia River Spire Snail and Giant Columbia River Limpet. Table A-24 (continued).

Sub-			Ex	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Hydraulic & Geomorphic Modifications		-	-	-			-	-			
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival, growth, and fitness. May affect spawning productivity			
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	productivity.			
	Altered substrate composition		Year round	Permanent	Continuous							
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous							
	Ecosystem Fragmentation	cosystem Fragmentation										
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness.			
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect survival, growth, and fitness.			
Trap a	and Haul Operation	IS										
	Operational Activities											

Operational Activities							
Fish capture, handling, and release	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a
							1

	n/a
llow recommendations for avoiding ects on fish passage.	May affect survival, growth, and fitness.
sign structures for transparency to nsport of wood, sediment, and ganic debris to the greatest extent acticable.	May affect survival, growth, and fitness.
l	n/a

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	Spire snail and Columbia River limpet are not expected to be the subject of trap and haul operations, however some potential for exposure to infrequent short-term water quality effects could occur. Should exposure occur, these stressors may impose short-term effects on survival, growth, and fitness. <u>All exposed life history stages (mountain sucker only)</u> : Water quality effects are similar to those described for accidental releases of toxic substances under Structures.	Require an operational TESC plan.	See effects for related stressors under Water Quality Modification
	Ecosystem Fragmentation								
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Passage barriers	Unintentional passage barriers imposed by operational limitations	n/a	n/a	n/a	n/a	n/a	n/a	

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.

Sub-	ub- :tivity Impact Mechanism/		Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Culver passag	rts (removed/replac e)	ed/retrofitted for fish							
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of construction noise 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of visual and physical disturbance 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 equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; 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 construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Glochidia larvae; 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.
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	<u>Glochidia</u> : Capture and removal of larvae impractical, high likelihood of larval mortality. <u>Adults and juveniles</u> : Adults appear insensitive to handling stress, however inadvertent dispersal when relocated can affect population productivity. Juvenile sensitivity to handling stress unknown. These species are also sensitive to effects on host fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause larval mortality. May affect adult population productivity. Effects on host fish may also affect population productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	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)	Glochidia; Juveniles; Adults	Glochidia:High likelihood of mortality from pump entrainment or impingement on screen filters.Juveniles and adults:Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	High likelihood of larval mortality from entrainment or impingement. The effects of juvenile and adult exposure to this stressor are expected to be low. Effects on host fish will indirectly affect population productivity.
		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.
		Stream bed disturbance (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.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	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. <u>Juvenile and adults</u> : 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/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Glochida; Juveniles; Adults	Glochidia:Direct injury or mortality from dredge entrainment.Juveniles and adults:Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity.Inadvertent dispersal may affect population productivity.See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications		-	-		-	-	-	-
		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>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels. <u>Juveniles and adults</u> : 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, productivity, and spawning success.
		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	Gill tissue in these species is sensitive to injury or clogging by elevated suspended sediment levels. <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).	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 adult and juvenile survival, growth and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								-
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects on these species. However, riparian modification resulting from fish passage related structure retrofits is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all submechanisms.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness.
	Altered stream bank and shoreline 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)	Juveniles; Adults			
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults			

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Sub-			Ex	posure	·		_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		<u>.</u>	-	-		-	-	
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juvenile and adult freshwater mussels. However, the extent of aquatic vegetation	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	May affect growth and fitness for intermediate-term period.
	Altered habitat complexity	Altered food web productivity, reduced foraging opportunity, reduction in available cover	educed in available Adults Modification caused by removing/ replative retrofitting structures for fish passage purposes is expected to be limited in ex- comparison to initial structure installative these effects will recover relatively rapion Therefore, the additional incremental efforts on HCP species from this impact mecha- are expected to be similarly minor.	modification caused by removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	during project construction.				
	Hydraulic & Geomorphic Modifications								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival, growth and fitness.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		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.	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 substrate composition and stability		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

HPA HCP Fish Passage Structures Exposure and Response Matrix for Western Ridged Mussel and California Floater Mussel. Table A-25 (continued).

Sub-			Exp	oosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation				-	-	-	-	
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	Effects on host species that affect abundance and distribution may in turn affect abundance and distribution of freshwater mussel species.	Follow recommendations for maintaining fish passage.	May affect abundance and distribution.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness.
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect survival, growth, and fitness.
Fish La	adders/Fishways								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of construction noise 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of visual and physical disturbance 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 equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.

Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	All life-history stages: The effect of construction noise 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).
	Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of visual and physical disturbance on California floater and western ridged mussels is a data gap.

Table A-25 (continued).	HPA HCP Fish Passage	Structures Exposure and	Response Matrix for V	Western Ridged Mussel and C	Calif
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Sub-			Ex	posure	1	7			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; 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 construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Glochidia larvae; 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.
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia: Capture and removal of larvae impractical, high likelihood of larval mortality. Adults and juveniles: Adults appear insensitive to handling stress, however inadvertent dispersal when relocated can affect population productivity. Juvenile sensitivity to handling stress unknown. These species are also sensitive to effects on host fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause larval mortality. May affect adult population productivity. Effects on host fish may also affect population productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	<u>Glochidia:</u> High likelihood of mortality from pump entrainment or impingement on screen filters. <u>Juveniles and adults</u> : Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	High likelihood of larval mortality from entrainment or impingement. The effects of juvenile and adult exposure to this stressor are expected to be low. Effects on host fish will indirectly affect population productivity.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : 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.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect survival at juvenile and adult life-history stages.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.

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fornia Floater Mussel.

Sub-	Lune of Machanism (Ex	posure	ľ	1 1	-		Deselting Effects of the
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. <u>Juvenile and adults</u> : 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/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Glochida; Juveniles; Adults	<u>Glochidia</u> : Direct injury or mortality from dredge entrainment. <u>Juveniles and adults</u> : Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity. Inadvertent dispersal may affect population productivity. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.
	Water Quality Modifications								
		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>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		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	Gill tissue in these species is sensitive to injury or clogging by elevated suspended sediment levels. <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).	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 adult and juvenile survival, growth and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects on these species. However, riparian modification resulting from fish passage related structure retrofits is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all submechanisms.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	These effects are expected to be insignificant.
	Altered stream bank and shoreline 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)	Juveniles; Adults		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 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		Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	These effects are expected to be insignificant.
	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		Encourage project designs that limit permanent alteration of habitat features.	These effects are expected to be insignificant.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults		Avoid disturbance of vegetation along stream.	These effects are expected to be insignificant.

Sub-											
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
	Aquatic Vegetation Modifications	-			<u>.</u>	<u>.</u>					
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juvenile and adult freshwater mussels. However, the extent of aquatic vegetation	De im alt co <u>Co</u> dis			
	Altered habitat complexity Altered for foraging of cover	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	modification caused by removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	du			
	Hydraulic & Geomorphic Modifications										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles;	<u>Juveniles and adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing				
	Altered flow regime	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		habitat suitability, and changes in food web complexity. This may limit foraging opportunities leading to decreased growth, fitness, and survival.	pro de ch su gro ex			
	Altered substrate composition		Year round	Permanent	Continuous						
	Altered groundwater- surface water exchange		Year-round	Permanent	manent Continuous						
	Ecosystem Fragmentation										
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	Effects on host species that affect abundance and distribution may in turn affect abundance and distribution of freshwater mussel species.	Fo ma			

Minimization Measures	Resulting Effects of the Submechanism
esign: Limit structural and poundment footprint to avoid eration of native vegetation mmunity to the extent practicable <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation ring project construction.	These effects are expected to be insignificant.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival, growth, and fitness.
llow recommendations for intaining fish passage.	May affect abundance and distribution.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness.
Rough	ened Channels								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of construction noise 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of visual and physical disturbance 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 equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
]	Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	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.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Glochidia 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.
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia:Capture and removal of larvaeimpractical, high likelihood of larvalmortality.Adults and juveniles:Adults and juveniles:insensitive to handling stress, howeverinadvertent dispersal when relocated canaffect population productivity.Juvenilesensitivity to handling stress unknown.These species are also sensitive to effects onhost fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause larval mortality. May affect adult population productivity. Effects on host fish may also affect population productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia: High likelihood of mortality from pump entrainment or impingement on screen filters. <u>Juveniles and adults</u> : Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	High likelihood of larval mortality from entrainment or impingement. The effects of juvenile and adult exposure to this stressor are expected to be low. Effects on host fish will indirectly affect population productivity.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : 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.
		Stream bed disturbance (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.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. <u>Juvenile and adults</u> : 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/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.

HPA HCP Fish Passage Structures Exposure and Response Matrix for Western Ridged Mussel and California Floater Mussel. Table A-25 (continued).

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Glochida; Juveniles; Adults	<u>Glochidia</u> : Direct injury or mortality from dredge entrainment. <u>Juveniles and adults</u> : Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity. Inadvertent dispersal may affect population productivity. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.
	Water Quality Modification								
		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	Adults and juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		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	Gill tissue in these species is sensitive to injury or clogging by elevated suspended sediment levels. <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).	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 adult and juvenile survival, growth and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual-decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								-
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects on these species. However, riparian modification resulting from fish passage related structure retrofits is expected to be limited in extent in comparison to initial structure installation. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all submechanisms.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness.
	Altered stream bank and shoreline 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)	Juveniles; Adults			
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults			

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Sub-	ub-		Exp	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modifications		-						
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juvenile and adult freshwater mussels. However, the extent of aquatic vegetation modification caused by removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness for intermediate-term period.
	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	<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.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications			-	-		-		-
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, larval, and juvenile life-history stages. May affect spawning productivity.
	Altered flow regime	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Aduns	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	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 substrate composition		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth fitness and survival		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology ma lead to alteration of the migratory corridor ar 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		
	Ecosystem Fragmentation								
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	Effects on host species that affect abundance and distribution may in turn affect abundance and distribution of freshwater mussel species.	Follow recommendations for maintaining fish passage.	May affect abundance and distribution.
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness.
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect survival, growth, and fitness.

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ctivity 'ype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Veirs									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of construction noise 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.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of visual and physical disturbance 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 equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	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.
		Exposure to toxic chemicals from accidental spills	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Glochidia larvae; 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.
	Dewatering and fish handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia:Capture and removal of larvaeimpractical, high likelihood of larvalmortality.Adults and juveniles:Adults appearinsensitive to handling stress, howeverinadvertent dispersal when relocated canaffect population productivity.Juvenilesensitivity to handling stress unknown.These species are also sensitive to effects onhost fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause larval mortality. May affect adult population productivity. Effects on host fish may also affect population productivity.

Sub-	- vity Impact Machanism/		Ex	xposure					
activity Type	Impact Mechanism/ Submechanism	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)	Glochidia; Juveniles; Adults	Glochidia: High likelihood of mortality from pump entrainment or impingement on screen filters. Juveniles and adults: Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	High likelihood of larval mortality from entrainment or impingement. The effects of juvenile and adult exposure to this stressor are expected to be low. Effects on host fish will indirectly affect population productivity.
		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.
		Stream bed disturbance (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.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. <u>Juvenile and adults</u> : 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/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Glochida; Juveniles; Adults	<u>Glochidia</u> : Direct injury or mortality from dredge entrainment. <u>Juveniles and adults</u> : Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity. Inadvertent dispersal may affect population productivity. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications	-		-	-	-	-	-	
		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>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. 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, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		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: 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).	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 adult and juvenile survival, growth and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
		Altered nutrient cycling	Year-round	Permanent	Continuous	Juveniles; Adults	Nutrient increases will lead to reduction in dissolved oxygen levels. See responses under altered dissolved oxygen levels.	No specific recommendations.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
		Introduction of toxic substances	During construction and maintenance	Short-term	Interannual–decadal (dependent on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

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ctivity Sype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications					-	-	-	•
	Altered shading, solar input, and ambient air temperature	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	Stressors related to extensive modification of riparian vegetation can impose a number of effects on these species. However, riparian modification resulting from fish passage related removal/ replacement/ retrofit of the structure is expected to be limited in extent in comparison to initial installation. Therefore, the additional	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect behavior and distribution. May affect survival, growth, and fitness.
	Altered stream bank and shoreline 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)	Juveniles; Adults	incremental effects on HCP species from this impact mechanism are expected to be similarly minor across all submechanisms.		
	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			
	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			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults			
	Aquatic Vegetation Modifications								
	Altered autochthonous production	Altered food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of freshwater mussels. However, the extent of aquatic vegetation modification caused by removing/ replacing/ retrofitting structures for fish passage purposes is expected to be limited in extent in comparison to initial structure installation and these effects will recover relatively rapidly. Therefore, the additional incremental effects on HCP species from this impact mechanism are expected to be similarly minor.	<u>Design</u> : Limit structural and impoundment footprint to avoid alteration of native vegetation community to the extent practicable <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness for intermediate-term period.
	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	<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.

Sub-	Impact Mechanism/ Submechanism	Exposure										
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Hydraulic & Geomorphic Modifications		-	-	-	-	-		-			
	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;	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. <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.	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, larval, 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	Aduits						
	Altered substrate composition		Year round	Permanent	Continuous							
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<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.					
	Ecosystem Fragmentation											
	Barriers to fish passage	n/a	n/a	n/a	n/a	n/a	Effects on host species that affect abundance and distribution may in turn affect abundance and distribution of freshwater mussel species.	Follow recommendations for maintaining fish passage.	May affect abundance and distribution.			
	Modified upstream transport of allochthonous nutrients	Decreased food web productivity induced by reduced upstream transport of allochthonous nutrients (e.g., marine derived nutrients) in fish carcasses	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced supply of allochthononous nutrients can have a profound effect on food web productivity, with long-term implications. Reduced abundance and availability of primary prey items is the most immediate effect, resulting in decreased survival, growth, and fitness. Over the long-term, riparian function can become diminished as nutrients are exported from the system and not replaced from allochthonous sources. This can lead to related effects on habitat complexity, influencing the availability of resting and spawning habitat, affecting adult spawning fitness and productivity.	Follow recommendations for avoiding effects on fish passage.	May affect survival, growth, and fitness.			
	Modified downstream transport of wood, sediment and organic material	Decreased habitat complexity and food web productivity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased availability of suitable rearing habitats and undesirable effects on food web productivity may lead to decreased survival, growth, and fitness	Design structures for transparency to transport of wood, sediment, and organic debris to the greatest extent practicable.	May affect survival, growth, and fitness.			

Sub-	Impact Mechanism/ Submechanism	Exposure									
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
Trap a	nd Haul Operation	IS									
	Operational Activities										
	Fish capture, handling, and release	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
	Accidental introduction of toxic substances	Exposure to fuel, lubricants, fish anesthetics or other toxicants from accidental operational spills	During capture, transport, and release operations	Short-term	Annual	Juveniles; Adults	Freshwater mussels are not expected to be the subject of trap and haul operations, however some potential for exposure to infrequent short-term water quality effects could occur. Should exposure occur, these stressors may impose short-term effects on survival, growth, and fitness.	Require an operational TESC plan.	See effects for related stressors under Water Quality Modification		
	Ecosystem Fragmentation										
	Alteration of migratory corridor	Alterations of migratory pathway caused by release location	n/a	n/a	n/a	n/a	Effects on host species that affect abundance and distribution may in turn affect abundance and distribution of freshwater mussel species.	Follow recommendations for maintaining fish passage.	May affect abundance and distribution.		
	Passage barriers	Unintentional passage barriers imposed by operational limitations	n/a	n/a	n/a	n/a					

n/a = Not applicable, no exposure to the submechanism and related stressors will occur and there are therefore no effects.