May 21, 2021 **Refer to NMFS No:** WCRO-2020-00923

James Mazza
Regulatory Division Chief
U.S. Army Corps of Engineers, San Francisco District
450 Golden Gate Avenue, 4th Floor, Suite 0134
San Francisco, California 94102-3406

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Fall Creek Fish Ladder Improvement Project in Felton, California (Corps File No. 2018-00863)

Dear James Mazza:

Thank you for your letter of April 16, 2020, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the San Lorenzo Valley Water District's (SLVWD) Fall Creek Fish Ladder Improvement Project (Project). This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action.

In the enclosed biological opinion, NMFS concludes the Project is not likely to jeopardize the continued existence of endangered Central California Coast (CCC) coho salmon or threatened CCC steelhead, nor is the Project likely to result in the destruction or adverse modification of critical habitat for CCC coho salmon or CCC steelhead. However, NMFS anticipates take of CCC steelhead and CCC coho salmon will occur due to Project construction and maintenance. An incidental take statement with non-discretionary terms and conditions is included with the enclosed biological opinion.

Regarding EFH, NMFS has reviewed the proposed project for potential effects and determined that the proposed project would adversely affect EFH for coho salmon managed under the Pacific Coast Salmon Fishery Management Plan (FMP). However, the anticipated effects are minor, temporary, or localized. Therefore, we have no practical EFH Conservation Recommendations to provide and no EFH Conservation Recommendations are included in this document.

In addition, as the SLVWD is copied on this letter, we note that the SLVWD and the County of Santa Cruz are in the process of developing the San Lorenzo River Watershed Conjunctive Use Plan to improve water-supply reliability and aquatic habitat within the San Lorenzo River watershed. Aside from the Fall Creek diversion (the subject of this consultation), the effects of the SLVWD's other water supply options within the San Lorenzo River basin on salmonids and their habitats have not been analyzed under the ESA or MSA. NMFS supports SLVWD and County of Santa Cruz's proactive approach to improving water supply reliability and instream habitat conditions for salmonids in the San Lorenzo River basin, and remains committed to assisting with the development of the plan. Once the Conjunctive Use Plan is completed and approved by the State Water Resources Control Board, we encourage the SLVWD to obtain appropriate coverage under the ESA and MSA for its future water operations.

Please contact Joel Casagrande, North-Central Coast Office in Santa Rosa, at (707) 575-6016 or Joel.Casagrande@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Alecia Van Atta
Assistant Regional Administrator
California Coastal Office

Enclosure

cc: Gregory Brown, Corps San Francisco District, Gregory.G.Brown@usace.army.mil
Carly Blanchard, San Lorenzo Valley Water District, cblanchard@slvwd.com
Kelli Camara, Santa Cruz County RCD, kcamara@rcdsantacruz.org
Wesley Stokes, CDFW Bay Delta Region, wesley.stokes@wildlife.ca.gov
Copy to ARN File # 151422WCR2020SR00080

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Fall Creek Fish Ladder Improvement Project

NMFS Consultation Number: WCRO-2020-00923

Action Agency: U. S. Army Corps of Engineers, Regulatory Division, San Francisco District

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Central California Coast steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	Yes	No
Central California Coast coho salmon (*O. tshawytscha*)	Endangered	Yes	No	Yes	No

Essential Fish Habitat and NMFS' Determinations:

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	No

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

Alecia Van Atta
Assistant Regional Administrator
California Coastal Office

Date: May 21, 2021

Table of Contents

1 INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

NOAA's National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402, as amended.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at NMFS' North-Central California Coast Office in Santa Rosa, California.

1.2 Consultation History

From January to April 2020, NMFS met with the San Lorenzo Valley Water District (SLVWD), the Resource Conservation District of Santa Cruz County (RCD), and Mike Podlech, SLVWD's consultant, to discuss the Project, and permitting timeline.

On February 25, 2020, SLVWD officially requested technical review of the draft Biological Assessment.

On April 9, 2020, the California Department of Fish and Wildlife (CDFW) and NMFS agreed that a CDFW engineer would complete the technical review of the Project design. On April 16, 2020, the Corps requested formal consultation with NMFS on the Fall Creek Project. On April 30, 2020, NMFS requested additional information regarding the Project's operations and maintenance plan and to obtain recent hydrology reports.

On May 18, 2020, SLVWD provided NMFS the final *Fall Creek Fish Ladder Improvement Project Biological Assessment and Essential Fish Habitat Assessment* (Podlech 2020). On May 21, 2020, SLVWD provided NMFS the *90% Fish Passage Design Hydraulic Report* prepared by Waterways Consulting Inc. (Waterways) (Waterways 2020).

On June 15, 2020, SLVWD provided NMFS the hydrology reports for water years (WY) 2014-2017 (Balance Hydrologics, Inc. 2015; 2018a; 2018b; 2019). On August 25, 2020, the CFDW notified NMFS that the Project design met NMFS (2011) and CDFW's fish passage requirements. On August 27, 2020, NMFS determined the information provided by SLVWD on

August 25, 2020 was sufficient to initiate formal consultation. On December 22, 2020, NMFS requested a 60-day extension to complete the consultation. The Corps agreed to the extension on January 22, 2021. NMFS requested a second 60-day extension on March 10, 2021. During a phone conversation on March 25, 2021, the Corps agreed to the second 60 day extension.

1.3 Proposed Federal Action

For ESA consultation, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). For EFH consultation, Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

The Corps proposes to issue a permit to the SLVWD under Section 404 of the Clean Water Act (33 U.S.C.1344) for the Fall Creek Fish Ladder Improvement Project (Project). The purpose of the proposed action is to modify their existing facility to comply with current NMFS fish passage standards while addressing structural deficiencies. The Project is located on Fall Creek approximately 0.4 stream miles upstream of its confluence with the San Lorenzo River, adjacent to Fall Creek Drive in Felton, Santa Cruz County, California.

The SLVWD proposes to improve/reconstruct an existing concrete fish ladder and diversion intake in Fall Creek. The Fall Creek fish ladder and diversion are part of SLVWD's Felton System, which provides water for the Town of Felton. Streamflow is diverted from Fall Creek via an intake within the fish ladder and is pumped through a pipeline to the nearby Kirby Water Treatment Plant in the Town of Felton.

The Project includes (1) site dewatering and fish relocation; (2) demolition and construction; and (3) the maintenance and operations of the ladder and diversion.

1.3.1 Site Dewatering and Fish Relocation

To facilitate construction activities, SLVWD proposes to dewater up to 200 linear feet of the channel in Fall Creek for up to 10 weeks between June 15 and October 15. The installation of the dewatering and stream bypass system will be the first construction activity in the stream channel. A cofferdam will be installed to bypass streamflow past the construction site. The cofferdam will consist of clean gravel-filled bags that will be wrapped in a sheet of plastic (visqueen). Gravity-fed bypass piping will be installed to divert streamflow around the Project site. The ends of the diversion pipes will be screened according to NMFS screening guidelines to prevent fish entrainment. Puddled water within the dewatered reach will be removed from the construction area using screened submersible pumps. Screens will meet NMFS (1997a) criteria. Water pumped from the construction area will be transferred to a settling basin before being discharged into Fall Creek downstream. The bypass system and cofferdam will be sized appropriately to handle expected summer base flow conditions. Once construction activities are complete, gradual re-watering and removal of cofferdams will minimize disturbance to the stream channel.

To reduce fish injury and mortality, a qualified biologist will capture and relocate fish outside of the construction area before and during dewatering activities. After isolating the construction area with block nets, the biologist will use a combination of NMFS-approved methods to capture, handle, and transport fish to the release location. Fish will be captured by seining, dip netting, or electrofishing. The biologist will place captured fish in a bucket filled with cool, aerated creek water. Captured fish will then be transported in the buckets by foot and released into suitable habitats upstream and/or downstream of the work area. The biologist will determine release locations prior to capture activities.

1.3.2 Demolition and Construction

Once the channel is completely dewatered, the existing structure will be demolished to facilitate construction. The contractor will remove 25 cubic yards (cy) of existing rock slope protection (RSP) located along the north bank of Fall Creek and adjacent to the existing fish ladder. The contractor will also remove a set of stairs leading to the existing diversion intake and grade approximately 300 square feet of streambank near the diversion to reduce the slope of the bank and provide a temporary access route for construction. The designated access route will provide a single entrance and exit for the contractor to access the site. Approximately 55 cy (0.004 acre) of one-quarter ton RSP will be placed along the newly graded slope above the intake to protect the channel banks and buried intake pipes between the grade control weir and the top of the fish ladder from damage during floods. Most of the RSP will be located above the 100-year flood elevation. Hydraulic modeling was used to calculate the size of RSP necessary to protect the structure and the bank. The RSP will be backfilled with native soils from the construction area replanted with native species.

Hand-driven electric, pneumatic, and gas-powered concrete demolition tools will be used to demolish the existing concrete fish ladder, intake pad and excavate bedrock. The fish ladder walls and floors will be reduced and roughened to the design height necessary to accommodate the new weir configurations. Up to 300 cy of substrate and bedrock will be excavated and removed to flatten the floor of the fish ladder and increase the width of each chamber to achieve a minimum chamber width of 8 feet. Concrete and bedrock will be disposed of outside of the construction area.

The Project aims to improve fish passage conditions and repair structural deficiencies by making several improvements to the fish ladder and diversion intake. These include modifying the four existing concrete weirs and constructing two additional concrete weirs downstream of the existing weirs to meet new design profile with 12-inch vertical drops. Concrete will be poured along the bottom of the channel and banks, keyed into existing concrete, and blended into the ground. The concrete will be a minimum of 8 inches thick and cover the channel's bed and banks up to a height of 15 feet. The concrete will stabilize the structure and prevent damage during high flows.

The steep slope of the channel requires two new weirs to reduce fish jump heights from 18 to 12 inches. The two new weirs will be poured at the downstream end of the ladder. The new weirs and pools will convert less than 25 linear feet of natural stream channel to concrete-lined fish ladder. Each weir will have a 4-foot high concrete weir wall with a 2-foot tall by 4-foot wide notch. Removable steel flashboards with V-notches cut into them will be bolted into the concrete weirs. The V-notch weir crests create plunging flows between each chamber with a water surface elevation difference between each weir crest of 12 inches. Non-toxic sealants will be used on the surface to protect it from degradation. Once the concrete is poured and sealed, the structure will be kept dewatered to allow the concrete to fully cure.

A new grade control weir will be constructed directly upstream of the intake to maintain water depths and promote sediment transport past the water intake. The 2.5-foot concrete weir will be located approximately 10 feet upstream of the ladder and diversion intake. The concrete footing of the weir will be poured a minimum of 2 feet below grade and blended to the RSP and concrete wall. There will be a 6-inch drop in water surface elevation at the grade control weir. Five boulders will be keyed into the streambed downstream of the ladder to facilitate pool formation at the ladder entrance.

The new fish ladder is designed to meet fish passage criteria for adult salmonids when streamflow through the ladder range from 3 to 70 cfs. The 70 cfs flow rate for adults was based on the NMFS and CDFW one percent annual exceedance flow criterion. At low flows, the ladder will operate as a series of plunging pools each separated by a jump; however, when streamflow reaches 26 cfs the weirs will transition into a single streaming flow.

NMFS (2001) guidelines for salmonid passage at stream crossings specify a maximum hydraulic drop between water surfaces of 6 inches for juveniles. A reconnaissance level assessment of existing channel conditions in Fall Creek was conducted by Podlech (2018). The assessment focused on identifying and measuring existing vertical drops in the Fall Creek channel at natural (e.g., step-runs and log jams) and legacy anthropomorphic channel features (e.g., boulder weir). The assessment documented several natural and anthropogenic vertical drops ranging between 12 and 48 inches upstream and downstream of the ladder at boulder weirs, step pools, and wood jams (Podlech 2018). In addition, the assessment noted that the habitat conditions upstream and downstream of the ladder were similar.

Upon review of Podlech (2018), NMFS approved a juvenile passage design variance from 6-inch to 12-inch vertical drops, and noted CDFW's concurrence with this variance. The variance was based on (1) the presence of existing natural barriers greater than 6 inches upstream and downstream of the fish ladder; (2) the similar habitat conditions, water temperatures, and juvenile steelhead population densities upstream and downstream of the ladder; (3) the documentation of strong juvenile site fidelity in other watersheds; (4) the apparent function of Fall Creek as a spawning and fry production site for seeding of the mainstem San Lorenzo River; and (5) the observed high use of the pools in the fish ladder by juvenile steelhead for rearing (Podlech 2018; NMFS 2019).

Improvements to the diversion intake system have been designed to meet the most conservative approach velocity requirements established by CDFG (2000) and NMFS (1997a) for all life stages of steelhead and coho salmon. The existing passive screening system will be lowered by 3.1 feet and relocated slightly to be parallel to streamflow and positioned in a constructed pool immediately upstream of the fish ladder. The passive (i.e., non-self cleaning) fish screen is designed to provide a maximum approach velocity of 0.083 feet per second (ft/sec), equivalent to one-quarter of the of 0.33 ft/sec maximum approach velocity for self-cleaning screens (Waterways Consulting 2014). This will continue to allow the smallest life stages of salmonids to freely swim away from the face of the screen (i.e., avoid impingement). Sweeping flows are expected to adequately provide for fish to continue to move past the facility and passively prevent the accumulation of debris on the screens.

Construction of the ladder will require the removal of small amounts of vegetation. This will consist primarily of young trees, all of which have a diameter at breast height (DBH) of less than 4 inches, as well as understory species such as berry, ivy, and ferns. A 24-inch diameter tree stump will be removed from the bank. All disturbed areas, not converted to concrete by the expanded fish ladder, will be replanted with native species.

The demolition and construction of the ladder and diversion intake will be completed in approximately 10 weeks and will occur between June 15th and October 15th.

1.3.3 Maintenance

The Project is designed to minimize operational requirements for the fish ladder and intake structure. For example, weir elevations will not need to be adjusted based on streamflow or season. Moreover, the improved designs are expected to reduce deposition of sediment within the ladder chambers. Nevertheless, periodic inspection and maintenance will be necessary. In conjunction with finalizing the designs, Waterways Consulting, Inc. will provide an Operations and Maintenance (O&M) manual to SLVWD for the maintenance and operation of the new fish ladder structure. The manual will outline specific operation and maintenance needs and responsibilities to ensure effective operation and timely response to adverse conditions at the fish ladder. It is anticipated that the manual will be adaptively modified over the first few years of operation, as additional site-specific opportunities and constraints are identified.

Anticipated regular maintenance procedures include, but are not limited to, sediment and debris removal, structural repairs, and replacement of damaged parts. During routine inspections, less than approximately one cy of boulders, cobbles, sediment, and woody debris may be hand-removed from the fish ladder entrance, exit, and pool and ladder bays, as necessary to maintain favorable fish passage conditions and function. The fish ladder and intake structure would not need to be dewatered to accomplish these maintenance activities, and fish relocation would therefore not occur.

Large-scale fish ladder maintenance (e.g., sediment removal) requiring site dewatering is anticipated to occur every 2-3 years. Fish relocation activities, including the installation of block nets upslope and downslope of project area and relocation of fish by a qualified biologist, would occur and a maximum of 200 cy of sediment and debris would be removed during each maintenance event.

1.3.4 Operations

During construction and upon completion of the Project, SLVWD will continue their diversions from Fall Creek in accordance with their existing State Water Resource Control Board (SWRCB) appropriative water right permit (Permit # 20123) signed on August 3, 1987. The permit is limited to a total diversion rate of 1.7 cfs and a total annual diversion volume of 1,059 acre-feet per year (afy). As a condition of the permit, bypass flows are required on Fall Creek to protect aquatic species. Minimum bypass flows are defined for dry years, and average and wet year types, and are determined by the San Lorenzo River's accumulated runoff at Big Trees (SLRBT) USGS gauge (Table 1).

Table 1. Fall Creek Seasonal Bypass Flow Requirements and thresholds for Dry Water Year Type.

Bypass flow requirements (cfs)		
	Wet-Season (Nov 1 - Mar 31)	Dry-Season (Apr 1 - Oct. 31)
Dry Years	0.75	0.5
Average & Wet Years	1.5	1

Dry Water Year Type Determination

Month	Cumulative Discharge @ SLRBT gage (acre-feet)
October	< 500
October – November	< 1,500
October – December	< 5,000
October – January	< 12,500
October – February	< 26,500

1.3.5 Fisheries, Habitat, and Streamflow Monitoring

The SLVWD will develop a Fisheries and Streamflow Monitoring Plan that will include monitoring techniques and methods that will be used to determine if the fish ladder is meeting fish passage design criteria, providing sufficient fish passage, and to evaluate habitat and fish responses to diversion operations. The plan will include biological resource monitoring, streamflow monitoring, and annual reporting. SLVWD will develop the plan in coordination with NMFS and CDFW and provide a final draft to NMFS for review at least 45 days before construction of the Project is initiated.

Streamflow monitoring and habitat surveys will be conducted to quantify changes in habitat downstream and the effects of water operations on habitat. Salmonid monitoring is reasonably expected to include the continuation of existing fall sampling of juvenile salmonids upstream and downstream of the diversion.

SLVWD and its contractors operate two streamflow gages in Fall Creek. Each gauge estimates streamflow and provides valuable data on streamflow upstream and downstream of the diversion, diversion rates, and bypass flow compliance. The fish ladder will be retrofitted with an updated gaging station, which includes real-time communications. Fisheries monitoring will be conducted under the ESA Section 10(a)(1)(A) permit for the Santa Cruz County Stream Habitat and Juvenile Salmonid Monitoring Program (see Section 2.4.5 of the Biological Opinion for a brief description of the permit activities and the effects of these activities). This program has established monitoring sites upstream and downstream of the diversion in Fall Creek.

1.3.6 Proposed Avoidance and Minimization Measures

As part of the proposed action, SLVWD plans to use several avoidance and minimization measures (AMMs) to protect aquatic species and habitats during construction and maintenance activities. The AMMs have been selected to protect water quality, stream processes, and riparian vegetation during construction and the operations and maintenance of the facility. For example, measures to protect aquatic species include the use of seasonal work windows for in-channel work (June 15 to October 15), exclusion screens upstream and downstream of the construction area, and training of construction personnel. For water quality protection, measures include allowing poured concrete to fully cure before contact with streamflow, dedicated staging and containment areas for fueling of equipment, minimized access points and areas of disturbance, use of erosion control and sediment detention devices, inspection and immediate repair of vehicles for fluid or grease leaks, and replanting of disturbed areas. Section 2.4.6 of the biological assessment provides a complete list of measures (Podlech 2020). Also, the Resource Conservation District of Santa Cruz County (RCDSCC) has prepared a mitigation, monitoring and reporting plan for the restoration of disturbed areas following construction (RCDSCC 2020).

We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would not.

2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and/or an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both the survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which “means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species” (50 CFR 402.02). The designations of critical habitat for species use the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ‘‘destruction or adverse modification’’ analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The 2019 regulations define effects of the action using the term “consequences” (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms “effects” and “consequences” interchangeably.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species’ likelihood of both survival and recovery. The species status section also helps to inform the description of the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.

2.2.1 Species Description and Life History

The biological opinion analyses the effects of the federal action on the following federally listed species (Distinct Population Segment [DPS] or Evolutionarily Significant Unit [ESU]) and designated critical habitat:

> **Endangered Central California Coast (CCC) coho salmon ESU** (*Oncorhynchus kisutch*)
> > Endangered (70 FR 37160; June 28, 2005)
> > Critical habitat (64 FR 24049; May 5, 1999);
>
> **Threatened Central California Coast (CCC) steelhead DPS** (*Oncorhynchus mykiss*)
> > Threatened (71 FR 834, January 5, 2006)
> > Critical habitat (70 FR 52488, September 2, 2005).

The CCC steelhead DPS includes steelhead in coastal California streams from the Russian River to Aptos Creek, and the drainages of Suisun, San Pablo, and San Francisco Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers. In addition, the DPS includes steelhead from one active artificial propagation program: the Don Clausen Fish Hatchery Program.[1] The CCC coho salmon ESU includes coho salmon from Punta Gorda in northern California, south to, and including, Aptos Creek in central California, as well as populations in tributaries to San Francisco Bay, excluding the Sacramento-San Joaquin River System. In addition, the ESU includes coho salmon from the following artificial propagation programs: the Russian River Coho Salmon Captive Broodstock Program[2], and the Southern Coho Salmon Captive Broodstock Program.[3]

The action area is within designated critical habitat for CCC steelhead and CCC coho salmon. CCC steelhead critical habitat is designated from the Russian River to Aptos Creek to a lateral extent of ordinary high water in freshwater stream reaches, and to extreme high water in estuarine areas. CCC coho salmon critical habitat is designated to include all river reaches assessable to listed coho salmon from Punta Gorda in northern California south to the San Lorenzo River in central California, and includes two tributaries to San Francisco Bay, Arroyo Corte Madera Del Presidio and Corte Madera Creek. Critical habitat consists of the water, substrate, and adjacent riparian zone of estuarine and riverine reaches (including off-channel habitats).

2.2.1.1 Steelhead Life History

Steelhead are anadromous forms of *Oncorhynchus mykiss*, spending some time in both fresh- and saltwater. Juveniles migrate to the ocean where they mature. Adult steelhead return to freshwater

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[1] Kingfisher Flat Hatchery previously had a small CCC steelhead hatchery program that released steelhead smolts into Scott Creek and the San Lorenzo River. That program was terminated in 2014.

[2] Formerly referred to as the Don Clausen Fish Hatchery Captive Broodstock Program.

[3] Formerly referred to as the Scott Creek/King Fisher Flats Conservation Program and the Scott Creek Captive Broodstock Program.

rivers and streams to reproduce, or spawn. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning in multiple years before death (Busby et al. 1996; Moyle 2002). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in central California coastal streams. Eggs (laid in gravel nests called redds), alevins (gravel dwelling hatchlings), fry (juveniles newly emerged from stream gravels), and other juvenile life stages all rear in freshwater until they migrate to the ocean where they reach maturity.

O. mykiss exhibit a variable life history. Coastal *O. mykiss* populations in central and southern California are classified into three principle life history strategies: fluvial-anadromous, lagoon anadromous, and freshwater resident or non-anadromous (Boughton et al. 2007). The anadromous forms of CCC steelhead are classified as "winter-run" steelhead because they emigrate from the ocean to their natal streams to spawn annually during the winter; although run times can extend into spring (Moyle 2002). Within the CCC steelhead DPS, adults typically enter freshwater between December and April, with peaks occurring in January through March (Wagner 1983; Fukushima and Lesh 1998). It is during this time that streamflow (depth and velocity) are suitable for adults to successfully migrate to and from spawning grounds. The minimum stream depth necessary for successful upstream migration is about 13 centimeters (cm), although short sections with depths less than 13 cm are passable (Thompson 1972). More optimal water velocities for upstream migration are in the range of 40-90 cm/s, with a maximum velocity beyond which upstream migration is not likely to occur of 240 cm/s (Thompson 1972).

Redds are generally located in areas where the hydraulic conditions limit fine sediment accumulations. Reiser and Bjornn (1979) found that gravels of 1.3-11.7 cm in diameter were preferred by steelhead. Survival of embryos is reduced when fines smaller than 6.4 mm comprise 20 to 25 percent of the substrate. This is because, during the incubation period, the intragravel environment must permit a constant flow of water in order to deliver dissolved oxygen and remove metabolic wastes. Studies have shown embryo survival is higher when intragravel velocities exceed 20 cm/hour (Coble 1961; Phillips and Campbell 1961). The number of days required for steelhead eggs to hatch is inversely proportional to water temperature and varies from about 19 days at 15.6˚ degrees (°) Celsius (C) to about 80 days at 5.6°C. Fry typically emerge from the gravel two to three weeks after hatching (Barnhart 1986). Other intragravel parameters such as the organic material in the substrate affect the survival of eggs to fry emergence (Shapovalov and Taft 1954; Everest et al. 1987; Chapman 1988).

Once emerged from the gravel, steelhead fry rear in edgewater habitats along the stream and gradually move into pools and riffles as they grow larger. Cover, sediment, and water quality are important habitat components for juvenile steelhead. Cover in the form of woody debris, rocks, overhanging banks, and other in-water structures provide velocity refuge and a means of avoiding predation (Shirvell 1990; Bjornn and Reiser 1991). Steelhead, however, tend to use riffles and other habitats not strongly associated with cover during summer rearing more than other salmonids. In winter, juvenile steelhead become less active and hide in available cover, including gravel or woody debris. Young steelhead feed on a wide variety of aquatic and terrestrial insects, and emerging fry are sometimes preyed upon by older juveniles. Water temperature can influence the metabolic rate, distribution, abundance, and swimming ability of rearing juvenile steelhead (Barnhart 1986; Bjornn and Reiser 1991; Myrick and Cech 2005).

Optimal temperatures for steelhead growth range between 10 and 19°C (Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005). Fluctuating diurnal water temperatures are also important for the survival and growth of salmonids (Busby et al. 1996).

Although variation occurs, CCC juvenile steelhead that exhibit an anadromous life history strategy usually rear in freshwater for 1-2 years (NMFS 2016b). CCC steelhead smolts emigrate episodically from freshwater in late winter and spring, with peak migrations occurring in April and May (Shapovalov and Taft 1954; Fukushima and Lesh 1998; Ohms and Boughton 2019). Steelhead smolts in California range in size from 120 to 280 mm (fork length) (Shapovalov and Taft 1954; Barnhart 1986). Smolts migrating from the freshwater environment may temporarily utilize the estuarine habitats for saltwater acclimation and feeding prior to entering the ocean.

Juvenile steelhead of the lagoon-anadromous life history rear in lagoons for extended periods (Smith 1990; Boughton et al. 2006; Hayes et al. 2008). Lagoons are a specific type of estuarine habitat where a seasonal impoundment of water develops after a sandbar forms at the mouth of the watershed, temporarily separating the fresh and marine environments (Smith 1990). Like other estuary types, bar-built lagoons can serve as important rearing areas for many fish and invertebrate species—including juvenile steelhead (Simenstad et al. 1982; Smith 1990; Robinson 1993; Martin 1995). Due to the combination of high prey abundance and seasonally warmer temperatures, juvenile steelhead that rear in lagoons have been found to achieve superior growth rates relative to upstream fish of the same cohort, and can therefore disproportionally represent future adult steelhead returns (Bond et al. 2008; Hayes et al. 2008). This is especially important considering that lagoon habitats often represent a fraction of the watershed area.

2.2.1.2 Coho Salmon Life History

The life history of the coho salmon in California has been well documented (Shapovalov and Taft 1954; Hassler 1987; Weitkamp et al. 1995). In contrast to the life history patterns of other anadromous salmonids, coho salmon in California generally exhibit a relatively simple three year life cycle. Adult salmon typically begin the immigration from the ocean to their natal streams after heavy late-fall or winter rains breach the sand bars at the mouths of coastal streams (Sandercock 1991). Coho salmon are typically associated with small to moderately-sized coastal streams characterized by heavily forested watersheds; perennially-flowing reaches of cool, high quality water; dense riparian canopy; deep pools with abundant overhead cover; instream cover consisting of large, stable woody debris and undercut banks; and gravel or cobble substrates (Sandercock 1991). Immigration continues into March, generally peaking in December and January, with spawning occurring shortly after arrival at the spawning ground (Shapovalov and Taft 1954).

When in freshwater, optimal habitats for coho salmon include adequate quantities of: (1) deep complex pools formed by large woody debris; (2) adequate quantities of water; (3) cool water temperatures [when maximum weekly average water temperatures exceed 18°C coho salmon are absent from otherwise suitable rearing habitat (Welsh et al. 2001); temperatures between 12-14° C are preferred; and the upper lethal limit is between 25-26°C.]; (4) unimpeded passage to spawning grounds (adults) and back to the ocean (smolts); (5) adequate quantities of clean spawning gravel; and (6) access to floodplains, side channels and low velocity habitat during high flow events. Numerous other requirements exist (i.e., adequate quantities of food, dissolved oxygen, low turbidity, etc.), but in many respects these other needs are generally met when the six freshwater habitat requirements listed above are at a properly functioning condition.

The eggs generally hatch after four to eight weeks, depending on water temperature. Survival and development rates depend, in part, on fine sediment levels within the redd. Under optimum conditions, mortality during this period can be as low as 10 percent; under adverse conditions of high scouring flows or heavy siltation, mortality may be close to 100 percent (Baker and Reynolds 1986). McMahon (1983) found that egg and fry survival drops sharply when fines make up 15 percent or more of the substrate. The newly-hatched fry remain in the redd from two to seven weeks before emerging from the gravel (Shapovalov and Taft 1954). Upon emergence, fry seek out shallow water, usually along stream margins. As they grow, juvenile coho salmon often occupy habitat at the heads of pools, which generally provide an optimum mix of high food availability and good cover with low swimming cost (Nielsen 1992). In the spring, as yearlings, juvenile coho salmon undergo a physiological process, or smoltification, which prepares them for living in the marine environment. Emigration timing is correlated with precipitation events and peak upwelling currents along the coast. Entry into the ocean at this time facilitates more growth and, therefore, greater marine survival (Holtby et al. 1990).

2.2.2 Status of the Listed Species

NMFS assesses four population viability[4] parameters to discern the status of the listed ESUs and DPSs and to assess each species ability to survive and recover. These population viability parameters are: abundance, population growth rate, spatial structure, and diversity (McElhany et al. 2000). While there is insufficient data to evaluate these population viability parameters quantitatively, NMFS has used existing information to determine the general condition of the populations in the CCC steelhead DPS, the CCC coho salmon ESU, and factors responsible for the current status of these listed species.

The population viability parameters are used as surrogates for numbers, reproduction, and distribution, which are included in the regulatory definition of "jeopardize the continued existence of" (50 CFR 402.02). For example, abundance, population growth rate, and distribution are surrogates for numbers, reproduction, and distribution, respectively. The fourth parameter, diversity, is related to all three regulatory criteria. Numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape-level scales.

2.2.2.1 CCC Steelhead DPS

Historically, approximately 70 populations of steelhead existed in the CCC steelhead DPS

[4] NMFS defines a viable salmonid population as "an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100- year time frame" (McElhany et al. 2000).

(Spence et al. 2008; Spence et al. 2012). Many of these populations (about 37) were independent, or potentially independent, meaning they had a high likelihood of surviving for 100 years absent anthropogenic impacts (Bjorkstedt et al. 2005). The remaining populations were dependent upon immigration from nearby CCC steelhead DPS populations to ensure their viability (McElhaney et al. 2000, Bjorkstedt et al. 2005).

While historical and present data on abundance are limited, CCC steelhead numbers are substantially reduced from historical levels. A total of 94,000 adult steelhead were estimated to spawn in the rivers of this DPS in the mid-1960s, including 50,000 fish in the Russian River –the largest population within the DPS (Busby et al. 1996). More recent estimates for the Russian River are on the order of 4,000 fish (NMFS 1997b). Abundance estimates for smaller coastal streams in the DPS indicate low but stable levels with recent estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Pudding, and Caspar creeks) of individual run sizes of 500 fish or less (62 FR 43937; August 18, 1997). Some loss of genetic diversity has been documented and attributed to previous among-basin transfers of stock and local hatchery production in interior populations in the Russian River (Bjorkstedt et al. 2005). In San Francisco Bay streams, reduced population sizes and fragmented habitat conditions has likely also depressed genetic diversity in these populations. For more detailed information on trends in CCC steelhead abundance, see Busby et al. 1996; NMFS 1997b; Good et al. 2005; Spence et al. 2008; Williams et al. 2011; and Williams et al. 2016.

CCC steelhead long-term population trends suggest a negative growth rate, indicating the DPS may not be viable in the long-term. Populations that historically provided enough steelhead immigrants to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead remain present in most streams throughout the DPS, roughly approximating the known historical range, CCC steelhead likely possess a resilience that has slowed their rate of decline relative to other salmonid species. The 2005 status review concluded that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future" (Good et al. 2005). On January 5, 2006, NMFS issued a final determination that the CCC steelhead DPS is a threatened species, as previously listed (71 FR 834).

The most recent status update concludes that steelhead in the CCC DPS remains "likely to become endangered in the foreseeable future", as new and additional information available since Williams et al. (2011) does not appear to suggest a change in extinction risk (Williams et al. 2016). In the most recent status review, NMFS concluded that the CCC steelhead DPS should remain listed as threatened (NMFS 2016a).

2.2.2.2 CCC Coho Salmon ESU

Historically, the CCC coho salmon ESU was comprised of approximately 76 coho salmon populations. Most of these were dependent populations that needed immigration from other nearby populations to ensure their long-term survival. Historically, there were 11 functionally independent populations and 1 potentially independent population of CCC coho salmon (Spence et al. 2008, Spence et al. 2012). Most of the populations in the CCC coho salmon ESU are currently doing poorly as a result of low abundance, range constriction, fragmentation, and loss of genetic diversity, as described below.

Brown et al. (1994) estimated that annual spawning numbers of coho salmon in California ranged between 200,000 and 500,000 fish in the 1940s, which declined to 100,000 fish by the 1960s, followed by a further decline to 31,000 fish by 1991. More recent abundance estimates vary from approximately 600 to 5,500 adults (Good et al. 2005). Williams et al. (2011) indicated that CCC coho salmon are likely to continue to decline in number. CCC coho salmon have also experienced acute range restriction and fragmentation. Adams et al. (1999) found that in the mid 1990's coho salmon were present in 51 percent (98 of 191) of the streams where they were historically present, and documented an additional 23 streams within the CCC coho salmon ESaU in which coho salmon were found for which there were no historical records. More recent genetic research has documented reduced genetic diversity within subpopulations of the CCC coho salmon ESU (Bjorkstedt et al. 2005). The influence of hatchery fish on wild stocks has likely also contributed to the lack of diversity through outbreeding depression and disease.

Available data from the few remaining independent populations suggests population abundance continues to decline, and many independent populations that in the past supported the species overall numbers and geographic distributions have been extirpated. This suggests that populations that historically provided support to dependent populations via immigration have not been able to provide enough immigrants for many dependent populations for several decades. The near-term (10-20 years) viability of many of the extant independent CCC coho salmon populations is of serious concern. These populations may not have enough fish to survive additional natural and human caused environmental change.

The CCC coho salmon ESU also includes coho salmon from the following conservation hatchery programs: the Russian River Coho Salmon Captive Broodstock Program at Don Clausen Fish Hatchery in Sonoma County, California, and the smaller Southern Coho Salmon Captive Broodstock Program at Kingfisher Flat Hatchery in the Scott Creek watershed, Santa Cruz County, California. While differing in size and funding, both programs were initiated in 2001 in response to severely depressed coho salmon abundances. Fish are collected from the wild, brought into the hatcheries, genetically tested, and spawned to maximize diversity and prevent inbreeding. In the hatchery, fish are raised to various ages, fed krill, tagged, and released into streams throughout the watersheds. This release strategy allows the fish to imprint on the creek with the aim that they will return to these streams as adults so they can spawn naturally. Juvenile coho salmon and coho salmon smolts have been released into several Russian River tributaries and coastal watersheds in San Mateo and Santa Cruz counties.

None of the five diversity strata defined by Bjorkstedt et al. (2005) currently support viable coho salmon populations. According to Williams et al. (2016), recent surveys suggest CCC coho salmon abundance has improved slightly since 2011 within several independent populations (mainly north of San Francisco bay), although all populations remain well below their high-risk dispensation thresholds identified by Spence et al. (2008). The Russian River and Lagunitas Creek populations are relative strongholds for the species compared to other CCC ESU populations, the former predominantly due to out-planting of hatchery-reared juvenile fish from the Russian River Coho Salmon Captive Broodstock Program. The most recent status review (NMFS 2016a) documents conditions for CCC coho salmon have not improved since the last status review in 2011 (Williams et al. 2016). The overall risk of CCC coho salmon extinction remains high, and the most recent status review reaffirmed the ESU's endangered status (NMFS 2016a). NMFS's recovery plan (NMFS 2012) for the CCC coho salmon ESU identified the major threats to population recovery. These major threats include roads, water diversions and impoundments, and residential development.

2.2.3 Status of CCC Steelhead and CCC Coho Salmon Critical Habitat

PBFs for CCC steelhead critical habitat within freshwater include:

1. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development;
2. Freshwater rearing sites with:
   a) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility;
   b) Water quality and forage supporting juvenile development; and
   c) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;
3. Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

PBFs for CCC steelhead critical habitat within estuarine areas include: areas free of obstruction and excess predation with: water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

For CCC coho salmon critical habitat, the following essential habitat types were identified: 1) juvenile summer and winter rearing areas; 2) juvenile migration corridors; 3) areas for growth and development to adulthood; 4) adult migration corridors; and 5) spawning areas (64 FR 24049). Essential features (or PBFs as discussed above) for coho salmon include adequate: (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (64 FR 24049).

The condition of CCC steelhead, and CCC coho salmon critical habitat, specifically its ability to provide for their conservation, has been degraded from conditions known to support viable salmonid populations. NMFS has determined that currently depressed population conditions are, in part, the result of the following human-induced factors affecting critical habitat[5]: logging, urban and agricultural land development, mining, stream channelization, and bank stabilization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation). Habitat impacts of concern include altered streambank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality/quantity, lost riparian vegetation, and increased sediment delivery into streams from upland erosion (Weitkamp et al. 1995; Busby et al. 1996; 64 FR 24049; 70 FR 37160; 70 FR 52488). Based on NMFS familiarity with the landscapes in which these critical habitats occur, these impacts continue to persist today. Widespread diverting of rivers and streams, as well as the pumping of groundwater hydraulically connected to streamflow, has dramatically altered the natural hydrologic cycle in many of the streams within the CCC steelhead DPS and CCC coho ESU which can delay or preclude migration and dewater aquatic habitat. Stream channelization, commonly caused by streambank hardening and stabilization, represents a very high threat to instream and floodplain habitat throughout much of the designated critical habitat for both species, as detailed within the CCC coho salmon and CCC steelhead recovery plans (NMFS 2012 and 2016b, respectively). Streambank stabilization confines stream channels and precludes natural channel movement, resulting in increased streambed incision, reduced habitat volume and complexity. Overall, the current condition of CCC steelhead and CCC coho salmon critical habitat is degraded, and does not provide the full extent of conservation value necessary for the recovery of the species.

The CZU Lightening Complex started as a series of lightening fires on August 16, 2020 across western Santa Cruz and San Mateo counties (California Department of Forestry and Fire Protection and California Department of Conservation 2020). The fire was fully contained on September 22, 2020, but burned a total of 86,509 acres. Portions of the burned area represented some of the highest quality habitat for salmonids in the Santa Cruz Mountains. Much of the burned areas in Fall Creek burned at low-intensities, and as a predominately redwood forest, most of the larger trees survived (Cal Fire and CDC 2020). Future winter storms may transport large quantities of ash, debris, and fine sediments into areas downslope from burned areas, including Fall Creek, in the near future.

2.2.4 Global Climate Change

Another factor affecting the rangewide status of CCC steelhead and CCC coho salmon and aquatic habitat at large is climate change. Impacts from global climate change are already occurring in California. For example, average annual air temperatures, heat extremes, and sea level have all increased in California over the last century (Kadir et al. 2013). Snowmelt from the Sierra Nevada has declined (Kadir et al. 2013). However, total annual precipitation amounts have shown no discernable change (Kadir et al. 2013). CCC steelhead and CCC coho salmon may have already experienced some detrimental impacts from climate change. NMFS believes the

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[5] Other factors, such as over fishing and artificial propagation have also contributed to the current population status of these species. All these human induced factors have exacerbated the adverse effects of natural environmental variability from such factors as drought and poor ocean productivity.

impacts on listed salmonids to date are likely fairly minor because natural, and local, climate factors likely still drive most of the climatic conditions steelhead and coho salmon experience, and many of these factors have much less influence on steelhead abundance and distribution than human disturbance across the landscape. In addition, CCC steelhead and CCC coho salmon, in the Santa Cruz Mountains, are not dependent on snowmelt driven streams and thus not affected by declining snow packs.

The threat to CCC steelhead and CCC coho salmon from global climate change is expected to increase in the future. Modeling of climate change impacts in California suggests that average summer air temperatures are expected to continue to increase (Lindley et al. 2007; Moser et al. 2012). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe et al. 2004; Moser et al. 2012; Kadir et al. 2013). Total precipitation in California may decline and the magnitude and frequency of dry years may increase (Lindley et al. 2007; Schneider 2007; Moser et al. 2012). Similarly, wildfires are expected to increase in frequency and magnitude (Westerling et al. 2011; Moser et al. 2012).

In the San Francisco Bay region[6], warm temperatures generally occur in July and August, but as climate change takes hold, the occurrences of these events will likely begin in June and could continue to occur in September (Cayan et al. 2012). Climate simulation models project that the San Francisco region will maintain its Mediterranean climate regime, but experience a higher degree of variability of annual precipitation during the next 50 years and years that are drier than the historical annual average during the middle and end of the twenty-first century. The greatest reduction in precipitation is projected to occur in March and April, with the core winter months remaining relatively unchanged (Cayan et al. 2012).

Estuaries may also experience changes detrimental to salmonids. Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia et al. 2002; Ruggiero et al. 2010). In marine environments, ecosystems and habitats important to juvenile and adult salmonids are likely to experience changes in temperatures, circulation, water chemistry, and food supplies (Brewer and Barry 2008; Feely 2004; Osgood 2008; Turley 2008; Abdul-Aziz et al. 2011; Doney et al. 2012). The projections described above are for the mid to late 21st Century. In shorter periods, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Cox and Stephenson 2007; Smith et al. 2007; Santer et al. 2011).

Finally, climate change is also affecting water circulation and temperature patterns in the marine environment. In fall 2014, and again in 2019, a marine heatwave, known as “The Blob”[7], formed throughout the northeast Pacific Ocean, which greatly affected water temperature and upwelling from the Bering Sea off Alaska, south to the coastline of Mexico. The marine waters in this region of the ocean are utilized by salmonids for foraging as they mature (Beamish 2018).

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[6] Both the San Francisco Bay and Monterey Bay regions exhibit similar Mediterranean climate patterns. The action areas are located within the Monterey Bay region.

[7] https://www.fisheries.noaa.gov/feature-story/new-marine-heatwave-emerges-west-coast-resembles-blob

Although the implications of these events on salmonid populations are not fully understood, they are having considerable adverse consequences to the productivity of these ecosystems and presumably contributing to poor marine survival of salmonids.

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The area directly impacted from construction activities is 200 feet of the channel in Fall Creek, and approximately 300 feet of Fall Creek immediately downstream of the dewatered area where temporary construction effects may occur. The construction site includes the dewatered area and associated north and south bank hillside up to mean high-water mark (MHWM). The area impacted by operation of the Fall Creek Fish Ladder and diversion includes approximately 0.4 miles of Fall Creek from the point of diversion to the confluence with San Lorenzo River.

2.4 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1 Description of the Fall Creek Watershed and the Action Area

Fall Creek is a perennial tributary to the middle mainstem San Lorenzo River in Felton and drains a watershed area of 3,155 acres (4.93 square miles). Most of the watershed is underlain by karst limestone geology. Streams that drain karst systems tend to sustain higher stream flows during the dry season (Balance Hydrologics Inc. 2018b). SLVWD's Fall Creek diversion intake is located at an elevation of 350 feet, approximately 0.4 miles upstream of the San Lorenzo River confluence. The watershed area upstream of the intake is 2,770 acres (4.33 square miles) and includes the 285-acre (0.45 square miles) Bennett Spring subbasin. Approximately 5.5 miles of mapped steam channel are located upstream of the diversion, but a boulder falls complex located approximately 2.5 miles upstream of the diversion is considered the upstream limit of anadromy (Becker and Reining 2008).

The fish ladder and diversion facility are bordered on the south and west by the Fall Creek Unit of Henry Cowell State Park, on the north by private residences on Fall Creek Drive, and on the south and east by private residences on Farmer Street. The creek flows through an incised 20-25-foot wide channel with nearly vertical 20-35 foot bedrock slopes on either side. The wetted channel occupies nearly all of the area between the bedrock banks. The forest canopy surrounding the channel consists of a mixed evergreen community including coast redwood, bay laurel, Douglas fir, coastal live oak, tanoak and madrone.

Fall Creek is a heavily shaded and cool stream, with temperatures regularly below 16.0°C upstream and downstream of SLVWD's diversion (Alley 2018a). Even though much of the creek is within Henry Cowell State Park, it is subject to large sediment inputs from steep hillslopes prone to landslides. The landscape is apparently still recovering from past clear-cut logging and limekiln operations (Alley 2009). Stream gradient is moderate to steep, and the channel is dominated by shallow, fast riffles with relatively few pools.

Water diversion operations have been ongoing since the construction of the Felton System in 1972. The SLVWD acquired the water right and Fall Creek diversion from California American Water in 2009. The system is entirely dependent on surface water withdrawals from Fall, Bennett, and Bull creeks to supply the Town of Felton. Bull Creek is a separate tributary to the San Lorenzo River.

Due to the small watershed size, peak streamflow in Fall Creek remain under 1,000 cfs (Balance Hydrologics, Inc. 2019). During the 2014 through 2017 WYs, SLVWD contracted with Balance Hydrologics, Inc. to gauge and analyze streamflow in Fall Creek to better understand how the operations may affect streamflow and aquatic habitat conditions. This monitoring includes the severe drought conditions of WYs 2014 and 2015, near-average conditions of WY 2016, and the record-setting wet conditions of WY 2017[8] (Balance Hydrologics, Inc. 2019). During this timeframe (Figure 1), the maximum estimated mean daily diversion rate from Fall Creek never exceeded 0.5 cfs, while the average daily mean diversion rate through this period was 0.23 cfs (Podlech 2020). For all WY types, streamflow in Fall Creek downstream of the diversion is typically between 1-3 cfs during the dry period, and 3-5 cfs during the winter period. In dry years, streamflow downstream of the diversion averages 0.8 cfs in the summer and 2.5 cfs in the winter. During the dry 2014 and 2015 WYs, there were periods during the end of the summer when streamflow downstream of the diversion was as low as 0.3 cfs (2014) and 0.13 cfs (2015) at which time diversion rates were 0.45 and 0.47 cfs, respectively (Figure 1**).**

[8] The 2017 WY was exceptionally wet throughout California. For the San Lorenzo River, it was estimated to 300 percent of mean 1937-2017 annual flow at SLRBT gage.

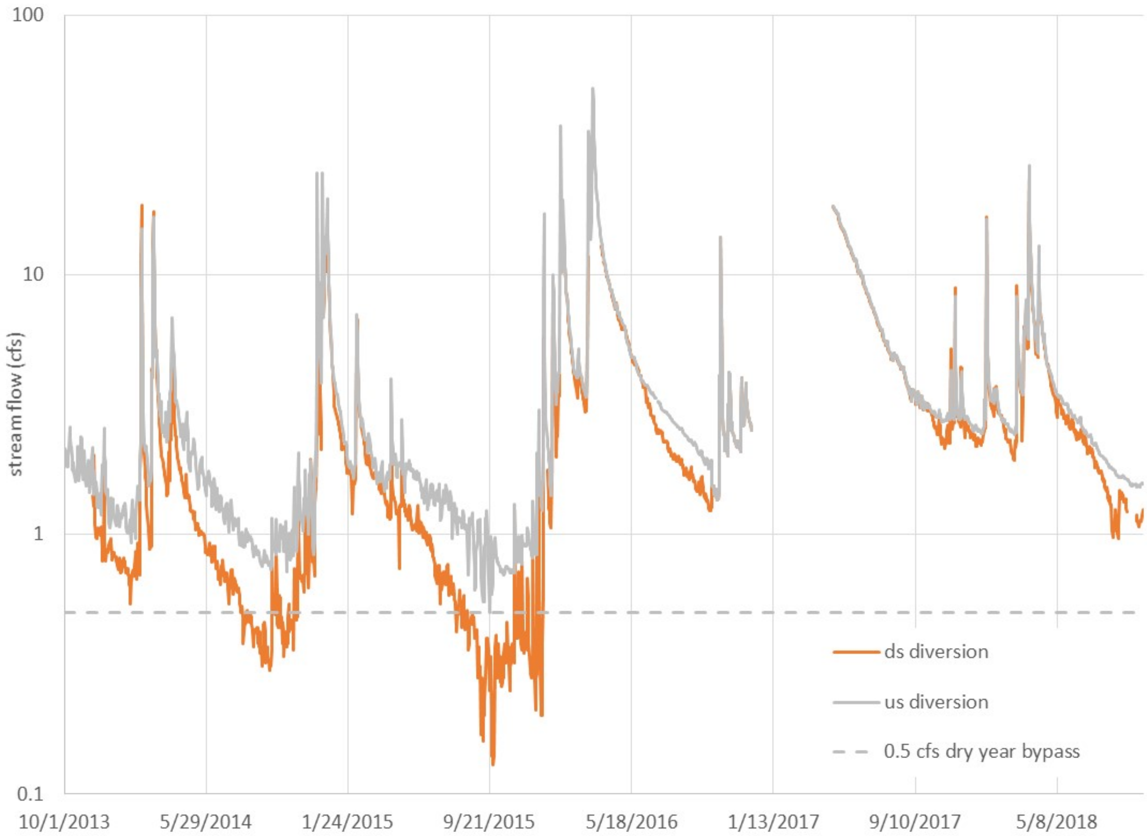

Figure 1. Streamflow in Fall Creek upstream (us) and downstream (ds) of the diversion during the 2014-2018 WYs (Data provided by Balance Hydrologics, Inc.).

The water right was issued in 1987, prior to the listing of CCC coho salmon and CCC steelhead under the ESA. At the time, however, CDFW[9] and the County of Santa Cruz requested the SWRCB include terms in the water right that would protect fisheries resources in Fall Creek below the diversion (Podlech 2020). The bypass flow requirements (Table 1) for Fall Creek are based on protest dismissal terms by CDFW. The water right does not explain the rationale used to arrive at the bypass flow requirements in Fall Creek.

2.4.2 Status of CCC Coho Salmon in the Action Area

Historically, CCC coho salmon were believed to inhabit all or most of the accessible coastal streams in Santa Cruz County. By the 1960's CCC coho salmon were believed present in seven populations in Santa Cruz County including the San Lorenzo River System (Bryant 1994). More recently, observations of coho salmon in the San Lorenzo River watershed have been scarce. One adult, natural origin coho salmon was caught in the Felton Diversion Dam on the San Lorenzo River in the winter of 2012/2013, and a very small number of hatchery-origin adults are

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[9] CDFW was named "California Department of Fish and Game", or "CDFG", at the time of the water right filings and were therefore referred to as CDFG in those records.

occasionally detected (i.e., tag detected) at the Felton Diversion dam tag antenna. Juvenile coho salmon were last captured at two electrofishing sites in Bean Creek, a tributary to Zayante Creek, during fall of 2005. That same year, two juvenile coho salmon were also captured in Zayante Creek near the confluence with Bean Creek (Hagar 2005), and others were observed in Bean Creek during snorkel surveys conducted by NMFS staff (Alley 2019). Coho salmon have not been found in Fall Creek during annual fall sampling of juvenile salmonids since 1981, or during the sampling for emergency repair of the Fall Creek fish ladder in 2013.

Although coho salmon have not been observed in Fall Creek in several decades, wild or hatchery strays from the Southern Coho Salmon Captive Broodstock Program have the potential to enter and spawn in Fall Creek in any given year. NOAA's Southwest Fisheries Science Center (SWFSC) operates a passive integrated transponder tag (PIT-tag) antenna array at the Felton Diversion Dam on the San Lorenzo River, located just downstream of the confluence with Fall Creek. Since the winter of 2016-17, a small number of tagged hatchery-origin adults have been detected at the antenna each year (Table 2).

Table 2. Number of PIT-tagged coho salmon detected at the Felton Diversion Dam antenna during the winters of 2016-17 through 2019-20. Source: Southwest Fisheries Science Center.

Winter	Number of coho salmon detected
2016-17	1
2017-18	1
2018-19	9
2019-20	2

Although the occurrence of juvenile coho salmon would be rare, there is potential for a small abundance of fish to be present during implementation of the ladder repair and subsequent maintenance activities of the project. Based on the information discussed above, we expect only a very small number of CCC coho salmon would utilize Fall Creek for spawning and rearing during project activities.

2.4.3 Status of CCC Steelhead in the Action Area

The San Lorenzo River watershed supports one of the largest steelhead populations within the Santa Cruz Mountains Diversity Stratum (NMFS 2016b). This population is functionally independent and likely provides frequent dispersal to nearby smaller coastal populations. Recovery criteria for the CCC steelhead San Lorenzo River population is a spawner density target of 3,200 (NMFS 2016b).

Complete annual estimates of adult steelhead escapement to the San Lorenzo River watershed do not exist. Spatially balanced spawning ground surveys conducted as part of California's Coastal Monitoring Program have produced partial estimates of escapement for the winters of 2012-13 to 2014-15 (Table 3). These estimates were made during the recent, multi-year drought between 2012 and 2016, and show a steep drop in abundance following the winter of 2013-14.

Table 3. Estimates of adult steelhead escapement to the San Lorenzo River watershed during the winters of 2012-13 to 2014-15 (Jankovitz 2013; Goin 2015; Goin 2016).

Winter	Point Estimate	Low 95% CI	High 95% CI
2012-13	648	0	1,717
2013-14	777	343	1,211
2014-15	188	76	300

Annual fall surveys for juvenile salmonids in Fall Creek have found multiple age classes of juvenile steelhead (Figure 2). Between 2014 and 2020, the mean juvenile steelhead density upstream of the ladder/diversion was 35 fish/100 feet (ft), and 38 fish/100 ft downstream of the diversion. In all years, captured juveniles in Fall Creek are dominated by small (50 – 80 mm fork length), age 0+, or young-of-the-year (YOY). The scarcity of yearlings and older juveniles during fall sampling is attributed to limited pool development in the naturally entrenched channel of Fall Creek (see Section 2.4.4 below for more details on instream habitat). This indicates Fall Creek's primary role in the greater San Lorenzo River population is to provide spawning habitat and fry production to seed the mainstem of the San Lorenzo where rearing conditions and overwintering habitat are more readily available (Jerry Smith, personal communication, March 2021). Finally, in addition to the annual fall sampling, in 2013, an emergency repair of the fish ladder required dewatering of a 194-foot reach of Fall Creek (Alley 2013). This capture and relocation effort yielded a total of 146 juvenile steelhead, for a density of 75 fish per 100 ft. Based on the information discussed above, CCC steelhead are expected to occur in the action area year round, including the proposed in-water work window of June 1 to October 15.

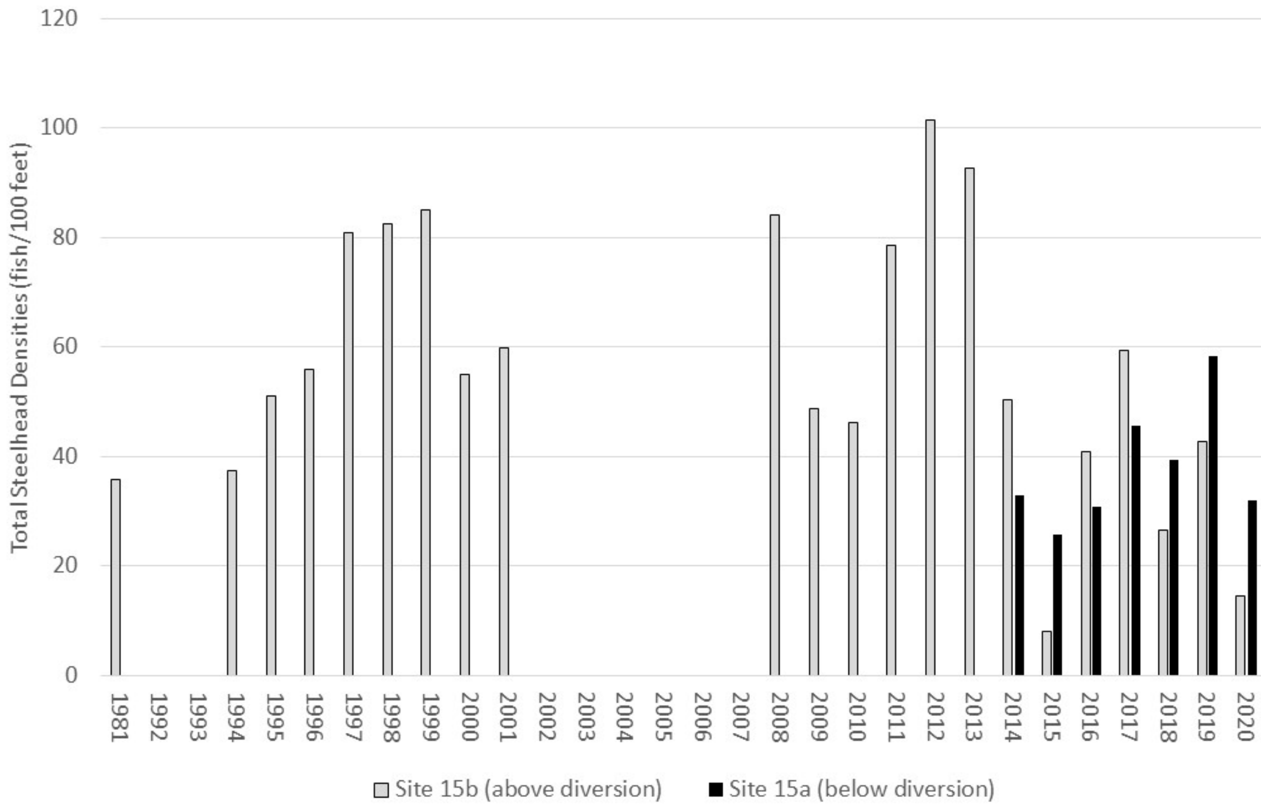

Figure 2. Annual fall juvenile steelhead densities in Fall Creek conducted by Don Alley and Associates (County of Santa Cruz 2019; Alley 2021).

2.4.4 Status of Critical Habitat in the Action Area

The action area is designated critical habitat for CCC steelhead and CCC coho salmon, and supports spawning, rearing, and migration of these listed species. PBFs include substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions.

Alley (2015) conducted habitat typing on Fall Creek upstream and downstream of the SLVWD intake. The approximately 0.4-mile reach immediately downstream of the diversion (Reach 15a) consists of a moderate-gradient (3 percent), entrenched, narrow and heavily shaded channel reach dominated by shallow riffle habitat with limited pool habitat for rearing yearling steelhead or coho salmon. Riffles account for 50 percent of habitat units, while pools account for only 25 percent of available habitat within the reach. Pools are generally shallow with mean and maximum depths of less than one-foot (Alley 2015). Upstream of the diversion, Alley (2015) found similar habitat conditions. While the upstream survey reach (Reach 15b) is less confined, riffles account for an even higher percentage (61 percent) of habitat, with pools accounting for only 24 percent.

Juvenile steelhead growth is very slow in Fall Creek. Age 0+ steelhead comprise the vast majority of the annual juvenile steelhead present throughout Fall Creek with most fish being less than 75 mm fork length by the end of their first growing season. Despite the relatively high summer baseflows, the slow growth of juvenile steelhead is attributed to poor pool development, degraded substrate, cool water temperatures and heavy shading (Alley 2009). This poor growth rate is consistent with other small, conifer-dominated streams of the Santa Cruz Mountains (Smith 1982; Hayes et al. 2008; Satterthwaite et al. 2009; Sogard et al. 2009).

Both natural and artificial barriers limit the movement of salmonids in rain-driven systems such a Fall Creek, especially during extended dry periods. In April 2018, SLVWD assessed salmonid passage in Fall Creek by conducting a barrier survey and critical riffle analysis and identified many vertical jumps in excess of the standard 6-inch juvenile passage criterion (Podlech 2018). Some of these features consist of legacy anthropogenic structures (e.g., boulder weir), but most are natural features such as fallen logs, woody debris jams, and step-run sequences.

In 1973, the previous owners constructed the water diversion and concrete fish ladder. Since then, the fish ladder has required major repairs multiple times, mainly coinciding with large storms. The last major modification occurred in 1995, when the ladder consisted of three concrete weirs and a Denil fish ladder. At that time, the owners removed the Denil ladder and constructed the current configuration with additional concrete weirs. Foundation elements attributed to the 1995 modifications were not keyed into the streambed and as a result have formed seepage paths under and around the weir, making it difficult for the SLVWD to operate and maintain the fish ladder (Waterways Inc. 2020).

The current fish ladder design does not meet NMFS fish passage criteria and requires salmonids to pass four 18-24 inch drops. The drop heights can limit juvenile salmonid movement, and each chamber (i.e., weir pool) is susceptible to sedimentation, periodic clogging, and damage from debris and sediment loads during storms, which can delay or block migration if not addressed in time. Despite these limitations, juvenile steelhead abundance above and below the ladder have been similar across paired sampling years (2014-2020), and in some years densities have been higher above the ladder than below (Figure 2).

The long-term effects of climate change have been presented above, and include changes to air and water temperature and the timing and magnitude of precipitation events that may affect steelhead, coho salmon, and critical habitat by changing water quality, streamflow levels, and salmonid migration in the action area. The threat to salmonids in the action area from climate change is likely going to mirror what is expected for the rest of Central California. NMFS expects that average dry season air temperatures in the action area would continue to increase, heat waves would become more extreme, and droughts and wildfire would occur more often (Hayhoe et al. 2004; Lindley et al. 2007; Schneider 2007; Westerling et al. 2011; Moser et al. 2012; Kadir et al. 2013). Many of these changes are likely to further degrade CCC steelhead and CCC coho salmon critical habitat within the action area by, for example, reducing streamflow during the dry season and raising summer water temperatures.

Such changes to the regional climate could also lead to drier forest conditions and an increased threat of wildfires. As noted above, the CZU Lightening Complex burned 86,509 acres across western Santa Cruz and San Mateo counties, including the upper portions of the Fall Creek drainage. An increase in frequency of such events could reduce canopy cover, large wood recruitment, and increase fine sediment yield to Fall Creek, which would have some adverse consequences on the PBFs for spawning and rearing habitats.

2.4.5 Previous ESA Section 7 Consultations and Section 10(a)(1)(A) Permits in the Action Area

In fall 2013, SLVWD conducted emergency repairs to the fish ladder. They sealed subsurface seepage, removed accumulated sediment, and replaced a failed boulder weir with a new concrete weir. As noted above, this emergency action required the capture and relocation of juvenile steelhead (146 individuals) from a section of the creek channel, consisting mostly of the existing fish ladder.

In 2018, NMFS and the Corps completed informal ESA section 7 consultation on the SLVWD's removal of 250 cy of debris from the fish ladder weir chambers. Up to 30 cy of coarse sediment (gravels and cobbles) was retained and placed on an existing cobble bar located immediately downstream of the fish ladder at the request of CDFW to allow for natural redistribution of those particles into downstream habitats. NMFS issued a concurrence letter on August 8, 2018. NMFS concluded the action was not likely to adversely affect CCC steelhead or the designated critical habitats for CCC steelhead or CCC coho salmon. NMFS concluded this limited one-time maintenance action would not affect CCC coho salmon due to the deterioration of the San Lorenzo River population, and the lack of observations of coho salmon in Fall Creek in recent decades.

NMFS has completed programmatic consultations for salmonid habitat restoration actions that include the action area of this project. These programmatic consultations include the NOAA Restoration Center's restoration program, the Corps' Regional General Permit #12 programmatic consultation, and the Santa Cruz Countywide Partners in Restoration Permit Coordination Program. These consultations anticipate a limited amount of take for juvenile salmonids during instream work conducted in the summer months. NMFS determined these restoration actions are likely to improve habitat conditions for listed species and that the limited amount of take anticipated is unlikely to affect future adult returns.

In addition to the consultations described above, NMFS also completed formal consultation on the County of Santa Cruz's Large Woody Material Management Program in Santa Cruz County. NMFS concluded the proposed suite of activities was likely to adversely affect ESA-listed fish species and critical habitat.

Activities conducted under the NMFS' ESA Section 10(a)(1)(A) research Permit 15824-2R: Santa Cruz County Stream Habitat and Juvenile Salmonid Monitoring Program - San Lorenzo, Soquel, Aptos and Corralitos Watersheds will occur within the action area. Salmonid monitoring approved under this permit includes carcass surveys, smolt outmigration trapping, and juvenile density surveys. In general, these activities are closely monitored and require measures to minimize take during the research activities. NMFS determined these research activities are unlikely to affect future adult returns.

2.5 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

Construction of the Project will take one year and is anticipated to begin in 2021. The Corps proposes to authorize this Project under Nationwide Permit 3, which expires in 2022, and will be renewed in five-year increments. In this biological opinion, we analyze the effects of construction and operations the first year, followed by maintenance and operations during subsequent years.

2.5.1 Fish Collection and Relocation

SLVWD will dewater the stream and fish ladder to facilitate construction and maintenance activities. To facilitate construction of the fish ladder, SLVWD proposes to dewater 200 linear feet of Fall Creek including the existing fish ladder structure. Some future maintenance activities will also require dewatering of up to 200 feet of the fish ladder approximately every 2-3 years. Prior to construction and maintenance activities, a qualified biologist will capture and relocate fish from the area before and during stream dewatering. Fish will be captured using a combination of seining, dip netting, and or electrofishing and relocated to suitable areas within Fall Creek outside the active construction site.

Fish capture and relocation activities pose a risk of injury or mortality to rearing juvenile salmonids. Any fish collecting gear, whether passive (Hubert 1996) or active (Hayes et al. 1996) has some associated risk to fish, including stress, disease transmission, injury, or death. The amount of unintentional injury and mortality attributable to fish capture varies widely, depending on the method used, the ambient conditions, and the expertise and experience of the field crew. Since fish relocation activities will be conducted by qualified fisheries biologists, effects to and mortality of juvenile salmonids during capture will be minimized. Based on information from other relocation efforts in California, NMFS estimates the number of injured or killed salmonids from capture and relocation activities would be less than three percent. Fish that avoid capture during relocation efforts may be exposed to stranding and desiccation, in the dewatered channel, which is described in the following section.

Capture and relocation activities will occur during the summer rearing period, prior to adult salmonid spawning migration and after smolt migration. Using the steelhead densities of 75 fish per 100 feet during the 2013 emergency action (described in Section 2.4.5 of this opinion), and accounting for potential annual variation in abundance, we assume up to 100 juvenile steelhead per 100 feet of creek may be present, or up to 200 fish in the proposed 200-foot dewatered reach. As described above, coho salmon have not been observed in Fall Creek during fall sampling since 1981. However, the presence of small number of adult detections at the Felton Diversion Dam PIT-tag antenna on the San Lorenzo River (Table 2) suggests that it is reasonable to conclude that spawning and subsequent rearing will occur in Fall Creek at some point during project activities. Although successful spawning may occur in Fall Creek, the entrenched channel, relatively steep gradient, and scarcity of pools are not optimal conditions for juvenile coho salmon. Because of these conditions, NMFS assumes juvenile coho salmon abundance will be low. In NMFS' judgement no more than 5 juvenile coho salmon per 100 feet of creek will be present, or up to 10 juvenile coho salmon in the 200-foot section of the creek.

NMFS expects no more than three percent of the salmonids captured during dewatering will be injured or killed during relocation activities. Given that we anticipate the capture of 200 juvenile steelhead and 10 juvenile coho salmon during this construction project, we expect no more than 6 juvenile steelhead, and no more than 1 juvenile coho salmon would be injured or killed during fish capture and relocation activities. For maintenance activities involving fish relocation and dewatering, we anticipate the capture of 200 juvenile steelhead and 10 coho during each event, which would result in no more than 6 juvenile steelhead and 1 juvenile coho salmon injured or killed during fish capture and relocation activities.

Sites selected in Fall Creek for relocating fish should have similar water temperature as the capture sites, and are expected to have adequate habitat available to support relocated fish. In some instances, relocated fish may endure short-term stress from crowding at the relocation sites. Relocated fish may have to contend with other fish causing increased competition for available resources such as food and habitat area. Frequent responses to crowding by steelhead include emigration and reduced growth rates (Keeley 2003). Fish released at the relocation sites may choose not to remain in these areas and move either upstream or downstream to areas that have more vacant habitat and a lower density of steelhead. As each fish moves, competition remains either localized to a small area or quickly diminishes as fish disperse. Recent monitoring in Fall Creek and elsewhere in the San Lorenzo River basin have shown that juvenile salmonid densities are below capacity (Alley 2021).

NMFS does not expect impacts from increased competition would be large enough to impact the survival of individual salmonids or the San Lorenzo River populations based on the small area affected and the relatively small number of individuals likely to be relocated. Once construction activities are completed, juvenile salmonids will have the ability to return to the previously dewatered portion of the action area.

2.5.2 Dewatering

Once initial capture and relocation efforts are complete, SLVWD proposes to isolate the dewatering area using a cofferdam and to bypass streamflow around the construction area. Construction and future maintenance activities will result in the dewatering of up to 200 feet of creek channel/fish ladder for up to 10 weeks.

The temporary cofferdam and water diversion structures in the creek are not expected to impact juvenile salmonid movements in Fall Creek beyond typical summer low-flow conditions. NMFS anticipates only minor and brief changes to streamflow outside of the dewatered construction area during the installation of the channel dewatering facilities. Once the cofferdam and bypass pipeline are installed and operational, streamflow above and below the work area should be the same as the pre-project conditions except within the dewatered work area where streamflow is bypassed. Juvenile steelhead surveys in nearby Soquel Creek showed high site fidelity among fish tagged in the summer and recaptured in the fall (Sogard et al. 2009). This suggests juvenile salmonid movement in Fall Creek in the summer is also limited and that their performance and behavior will not be impaired by the separation of habitats upstream and downstream of the dewatered area for up to 10 weeks.

Juvenile salmonids that avoid capture may die from stranding and desiccation or from being crushed by equipment or foot traffic if not found by biologists as water levels recede within the area. However, due to fish relocation efforts, NMFS expects the number of juvenile steelhead or coho salmon that would die from stranding during dewatering activities would be an additional two percent of the fish within the work site prior to relocation and dewatering. NMFS expects no more than 4 juvenile steelhead and 1 coho salmon will avoid capture during relocation efforts and be harmed or killed.

Dewatering operations may affect salmonids by temporarily preventing juvenile salmonids from accessing the area for forage; and dewatering activities may affect the function of critical habitat by reducing forage for juveniles in the dewatered area. Benthic (bottom dwelling) aquatic macroinvertebrates are an important food source for salmonids; they may be killed, or their abundance reduced when creek habitat is dewatered (Cushman 1985). However, effects to aquatic macroinvertebrates resulting from streamflow diversions and dewatering will be temporary because construction activities will be relatively short-lived. Rapid recolonization, typically within one to two months, of disturbed areas by macroinvertebrates is expected following re-watering (Cushman 1985; Thomas 1985; Harvey 1986). For this reason, we expect the function of critical habitat will return to its pre-project level before adults and smolts use the action area for migration. In addition, the effect of macroinvertebrate loss on juvenile salmonids is likely to be negligible because food from upstream sources (via drift) would be available downstream of the dewatered areas via streamflow diverted around the project work site or from terrestrial sources. NMFS expects fish will be able to find food and cover outside of the action area as needed to maintain their fitness during project construction. Based on the small area of impact and temporary nature of the action, we anticipate the impacts to PBFs for rearing habitat will be minimal and restored quickly after the dewatering system is removed.

2.5.3 Increased Sediment Mobilization and Other Contaminants

Construction and maintenance activities related to the project will result in the disturbance of the creek bed and banks due to equipment/personnel access, channel excavation, construction of weirs, relocation of the water intake, and placement/removal of cofferdams. These types of activities have been shown to result in temporary increases in turbidity (reviewed in Furniss et al. 1991; Reeves et al. 1991; Spence et al. 1996). Following construction, disturbed substrate could affect water quality and critical habitat in the action area in the form of small, short-term increases in turbidity during cofferdam removal and subsequent rainfall events.

Sediment may affect salmonids in several ways. High concentrations of suspended sediment can disrupt normal feeding behavior and efficiency (Cordone and Kelly 1961; Bjornn et al. 1977; Berg and Northcote 1985), reduce growth rates (Crouse et al. 1981), and increase plasma cortisol levels (Servizi and Martens 1992). High and prolonged turbidity concentrations can lower dissolved oxygen in the water column, reduce respiratory function, lower disease tolerance, and even cause fish mortality (Sigler et al. 1984; Berg and Northcote 1985; Gregory and Northcote 1993; Velagic 1995; Waters 1995). Even small pulses of turbid water may cause salmonids to disperse from established territories (Waters 1995), which can displace fish into less suitable habitat and/or increase competition and predation, decreasing survival. In addition, increased sediment deposition can fill pools and reduce the amount of cover available to fish, decreasing the survival of juvenile salmonids (Alexander and Hansen 1986).

Chronic elevated sediment and turbidity levels may adversely affect salmonids and their critical habitat; however, the temporary increases in sedimentation and turbidity levels associated with the Project are not expected to rise to a level that would alter behavior, injure, or kill salmonids present in the action area. SLVWD has proposed several measures to stabilize and prevent the mobilization of sediment post-construction. These measures include applicable stormwater BMPs such as erosion control fabric, silt fences, check dams, and revegetating disturbed areas with a native seed mix post-construction. NMFS expects any sediment or turbidity generated by construction activities would be minor and localized (not extend more than 300 feet downstream of the work site), well below levels known to cause injury or harm to salmonids. NMFS does not anticipate harm, injury, or behavioral impacts to CCC steelhead or CCC coho salmon associated with exposure to elevated suspended sediment from project activities. Regarding critical habitat, the temporary exposure of habitats to increased sedimentation or turbidity is not expected to reach the scale where the physical or biological features of critical habitat will be altered, and therefore the ability of critical habitat to support listed species' conservation needs in the action area will be maintained.

Construction and maintenance operations in, over, and near surface water have the potential to release debris, hydrocarbons, concrete/cement, and similar contaminants into surface waters. Potential contaminants that could result from projects like these include wet and dry concrete debris, fuel and lubricant for construction equipment, and various construction materials. If introduced into aquatic habitats, debris could impair water quality by altering the pH, reducing oxygen concentrations as the debris decompose, or by introducing toxic materials such as hydrocarbons or metals into the aquatic habitat. Oils and similar substances from construction equipment can contain a wide variety of polynuclear aromatic hydrocarbons (PAHs) and metals. PAHs can alter salmonid egg hatching rates and reduce egg survival as well as harm the benthic organisms that are a salmonid food source (Eisler 2000).

Use of heavy equipment and storage of materials is required for the construction of the Project, and may also be required for large-scale maintenance activities. As a result, if not properly contained, contaminants (e.g., fuels, lubricants, hydraulic fluids, concrete) could be introduced into the water system, either directly or through surface runoff. The effects described above for contaminants have the potential to temporarily degrade habitat and harm exposed fish. However, the project includes avoidance and minimization measures to address spills, avoid uncured concrete from coming into contact with live water, and preventing the introduction of construction debris and contaminants into the action area (Podlech 2020). Due to these measures, conveyance of toxic materials into Fall Creek during project implementation and maintenance is not expected to occur and the potential for the project to degrade critical habitat and harm salmonids is improbable.

2.5.4 Channel Modification and Vegetation Removal

The Project will require grading of the channel bed and banks, construction of concrete and rock weirs and installation of RSP. Grading of the channel is necessary to add and deepen the weirs and plunge pools, and to reposition the diversion intake. RSP is necessary to protect the slopes near the inlet to the fish ladder, and a concrete lined fish ladder was necessary to provide durable and secure fish passage. The RSP will be located on the slopes above the channel with nearly all of it above the 100-year water surface elevation.

In general, the stabilization of a stream banks and channel with concrete or large rock limits the stream's ability to generate channel sinuosity and form in-channel habitat diversity. Over time, this can result in channel incision (Schmetterling et al. 2001). The use of RSP for bank stabilization can also limit establishment of riparian vegetation, escape cover and food production utilized by salmonids (Schmetterling et al. 2001).

As described in Section 2.4.1 above, Fall Creek through the action area is naturally incised, within a 20-25-foot wide channel and nearly vertical 20-35-foot bedrock slopes on either side. The wetted channel bottom occupies nearly all of the area between the bedrock slopes. This natural channel morphology is not conducive to channel sinuosity or pool development. Although the ladder and weirs will be made from concrete, the pools within the ladder will offer rearing habitat for juvenile salmonids as has been shown in the past. The weir pools will range from 2 to 4 feet deep and will increase pool availability and volume within the action area, which is limited (Alley 2015; Podlech 2018). As described above, juvenile steelhead are routinely observed utilizing the existing fish ladder weir pools for rearing (Alley 2013; Podlech 2020).

The replacement and expansion of the fish ladder will result in the conversion of less than 25 feet of natural channel to concrete. While this conversion is permanent, the banks of Fall Creek in this area are steep and consist primarily of exposed bedrock (i.e., the banks are already "stabilized"). The resulting expansion of limited pool habitat is expected to provide suitable rearing habitat for juvenile steelhead (and coho salmon when coho salmon are present).

The proposed channel modifications for the new ladder are not expected to alter incision rates. In fact, the slope of the new ladder will be lower than the existing structure, and its larger width and flow capacity is expected to reduce velocities and shear stress at the outlet of the ladder. Nearly all of the proposed RSP will be placed above the 100 year flood elevation. The addition of the RSP is unlikely to further stabilize banks or constrict channel sinuosity in the naturally armored channel.

Maintenance activities will include the removal of accumulated sediments from the fish ladder pools. The SLVWD would prefer to treat excavated sediments from the ladder as they did during the 2018 maintenance of the ladder, when excavated sediments were placed onto a dry gravel bar immediately downstream of the ladder and allowed to disperse naturally during subsequent high flows. This placement was at the request of CDFW. Should SLVWD implement this practice in the future, NMFS expects this would have no adverse impact on rearing juvenile salmonids because it will be dispersed on dry land adjacent to the wetted channel. Instead, implementation of this action would sustain gravel and cobble transport downstream of the ladder, which is important for maintaining adequate spawning and rearing habitats in this section of the creek.

The removal of riparian vegetation for construction of the new ladder is limited due to the scarcity of vegetation along the bedrock channel. A small number of trees with a DBH of 4 inches or less and one, 24-inch tree stump will be removed. All RSP will be backfilled with local sediments and replanted with native species. All other disturbed areas not converted to concrete will be replanted. NMFS expects the small amount of vegetation affected during construction will be localized and be mostly temporary.

NMFS does not expect this minor increase in channel conversion to cement or rock or the minor amount of vegetation removal to accommodate a larger and more appropriate fish ladder design will diminish the value of critical habitat PBFs in the action area, including rearing capacity for juvenile CCC steelhead or coho salmon. Thus individual salmonids are unlikely to experience adverse effects from this small loss of natural channel.

2.5.5 Fish Ladder Improvements and Fish Passage

The proposed design improvements for the fish ladder facility have been approved by NMFS and CDFW. The approval of the ladder design by the agencies was based on a field reconnaissance by Podlech (2018), which found existing, natural steps in the channel up to 12 and 48 inches upstream and downstream of the ladder. The proposed ladder steps will not exceed 12 inches.

The improvements are expected to improve fish passage for both adult and juvenile salmonids by reducing jump heights and increasing pool depths below the weirs. The structural improvements will increase passage efficiency and access to approximately 2.5 miles of spawning and rearing habitat in Fall Creek upstream of the ladder. The pools below each weir are sized to provide adequate pool volume that will dissipate energy generated from the water plunging over the weirs without becoming excessively turbulent at design passage flows. The improved fish ladder is designed to meet fish passage criteria for adult salmonids when streamflow through the ladder range from 3.0 to 69.6 cfs. These adult salmonid design flows (69.6 cfs) are based on NMFS and CDFW one percent annual exceedance flow criterion (Waterways Consulting Inc. 2020). Flows below 3.0 cfs are not expected to facilitate fish passage through the action area, regardless of the ladder. Considering the design flows, we do not expect the new ladder will impede or delay the passage of adult salmonids to upstream habitat.

The ladder designs are also intended to reduce maintenance needs of the structure, including sediment accumulation and retention within the ladder. Finally, the larger and deeper weir pools within the new ladder will provide greater access and availability to limited pool habitat for juvenile steelhead rearing.

2.5.6 Fall Creek Diversion Intake

Water diversion intakes can be a major source of potential injury or mortality of fishes (Spencer 1928; Bell 1991). Entrainment, impingement, and delay/predation are the primary contributors to the injury or mortality of juvenile salmonids. Entrainment occurs when fish are drawn into the diversion, and impingement occurs when a fish is not able to avoid contact with a screen surface, trash rack, or debris at the intake. This may cause bruising, descaling and other injuries. Impingement, if prolonged, repeated, or occurring at high velocities, also causes direct mortality. Delay at intakes increases predation risk by stressing or disorienting fish and/or by providing habitat for predators.

Repositioning of the Fall Creek Diversion intake will meet NMFS' guidelines on intake structure placement, alignment, and screening materials (NMFS 1997a). The new fish screen is designed to provide a maximum approach velocity of 0.083 feet per second (ft/sec), equivalent to one-quarter of the of 0.33 ft/sec maximum approach velocity for self-cleaning screens (Waterways Consulting Inc. 2020). The design approach velocity of 0.083 ft/sec will allow steelhead and coho salmon fry and juveniles to safely swim away from the screen face without impingement. Given the proposed design, NMFS does not expect injury or mortality of steelhead or coho salmon from impingement or entrainment at the new screened intake.

2.5.7 Diversion Operations

The future operation of the Fall Creek diversion will continue to reduce streamflow in Fall Creek. Potential consequences of streamflow reductions include impacts to fish passage and movement, and reduced quantity and quality of instream habitat. SLVWD proposes to continue operating the Fall Creek diversion in accordance with their existing water right and bypass flow requirements (Table 1).

2.5.7.1 Effects on Fish Passage

SLVWD contracted with D.W. Alley & Associates (Alley 2018b) to assess streamflow requirements for fish passage in Fall Creek downstream of the diversion. The assessment was conducted using CDFW's critical riffle analysis, which compares the relationship between the depth of water and stream discharge to estimate the physical limitations of each life stage at the shallowest downstream riffle in a stream (Thompson 1972; CDFW 2012). Under this analysis, a riffle is considered passable when the minimum depth criteria is met over a contiguous 10 percent of the riffle's wetted width. Alley (2018b) used alternative minimum depth criteria based on extensive personal observations of regional fish sizes (i.e., fish height), and observations of fish passing through shallow riffles in regional streams. The product of this assessment was a set of recommendations for instream flow requirements in Fall Creek capable of providing suitable fish passage for various salmonid life stages (Table 4).

Table 4. Recommended minimum depth and streamflow requirements for adult and juvenile steelhead and coho salmon passage at critical riffles in Fall Creek (table modified from Alley 2018b).

Species (activity)	Minimum Depth feet (*inches*)	Primary Timing of Movement	Instream Flow (cfs) for Passage
Steelhead adult (up-migration)	0.4 – 0.6 (*4.8 – 7.2*)	Mid-December – Mid-April	17.1 – 27.4
Coho salmon adult (up-migration)	0.4 – 0.6 (*4.8 – 7.2*)	Mid-December – End of February	17.1 – 27.4
Steelhead adult - kelts (out-migration)	0.3 − 0.4 (*3.6 – 4.8*)	January – April	12.0 – 17.1
age 1+ and 2+ juvenile steelhead (smolt/pre-smolt out-migration) age 1+ juvenile coho salmon (smolt/pre-smolt out-migration)	0.2 (*2.4*)	Mid-March – End of June	7.1
age 0+ juvenile steelhead and coho salmon (movement - migration)	0.1 (*1.2*)	April – End of June	1.0 – 2.0 (flow continuity with San Lorenzo River)

<u>*Adult Steelhead and Coho Salmon Passage*</u>. Balance Hydrologics, Inc. (see Appendix B, Podlech 2020) analyzed the frequency at which Fall Creek streamflow upstream and downstream of the diversion exceeded the Alley (2018b) streamflow recommendations of 17.1 and 27.4 cfs for upstream adult migration for the 2014-2017 WYs. They found streamflow in Fall Creek upstream of diversion exceeded mean daily flows of 17.1 cfs on an annual average of 20.8 days during the adult steelhead migration period (December 15 through April 30), with a range of 0 days in WY 2014, to 121 days in WY 2017. During the same period, streamflow in Fall Creek downstream of the diversion exceeded 17.1 cfs on an annual average of 20.5 days, also with a range of 0 days in WY 2014, to 121 days in WY 2017. The only difference between the frequency of flows upstream and downstream exceeding 17.1 cfs occurred in WY 2016, when streamflow exceeded 17.1 cfs on 21 days upstream of the diversion compared to 20 days downstream of the diversion. On the one day when the criteria was not met downstream of the diversion but was met upstream of the diversion, daily mean streamflow upstream of the diversion was 17.2 cfs, the streamflow value for below the diversion was not available, and the diversion rate was 0.29 cfs. We can infer the flow downstream of the diversion on this one day was approximately 16.9 cfs, which is likely still passable to adults across short riffles. Finally, for the higher recommended instream flow (27.4 cfs), the analysis showed no difference between upstream and downstream frequencies of flows exceeding 27.4 cfs during the analyzed period.

Unlike the information discussed above, Balance Hydrologics Inc. did not prepare similar analyses per the recommended flows for emigrating kelts. Using the 12.0 cfs recommended minimum streamflow from Alley (2018b) and a comparison of the reported daily mean streamflow upstream and downstream of the diversion, the 12.0 cfs minimum criteria was not met below the diversion on 1 day in WY 2014, and 2 days in WY 2016. In 2014, the one day when flows downstream were less than the 12.0 cfs criteria, the mean daily flow downstream was 11.95 cfs compared to 12.82 cfs upstream (0.24 cfs reported daily diversion rate) [10]. In 2016, on the two days when flows downstream were less than the 12.0 cfs criteria, daily mean streamflow was 12.55 upstream and 11.87 cfs downstream; and 12.03 upstream and NA (not available) downstream of the diversion; on both dates the rate of diversion was 0.14 cfs. Based on this data, flows downstream of the diversion met the 12.0 cfs criteria at a similar frequency as the upstream reach. On the few occasions in which streamflow upstream was above 12.0 cfs and the downstream reach was below 12.0 cfs, mean daily flow in the downstream reach remained very close to the 12.0 cfs criteria. Finally, using critical riffle depth measurements and streamflow during 2015 (driest year), Alley (2018b) concluded that a diversion of up to 0.5 cfs in the months of January through April would result in a slight reduction in water surface elevation and depth within the thalweg, and therefore was "not likely to significantly impede passage of emigrating adult kelts". However, the diversion rates during this time of year never approach 0.5 cfs, and are typically less than 0.25 cfs.

Based on the relatively low maximum and steady rate of diversion, the proposed operations do not appear to alter the hydrograph of Fall Creek to the extent that would restrict adult steelhead or coho salmon fish passage through the action area. Therefore, NMFS does not expect the proposed continuance of these operations will adversely affect the migration or spawning of either species, nor diminish the value or function of PBFs and associated conservation elements for migration and spawning in designated critical habitats.

Age 1+ and Smolt and Yearling Fish Passage. Balance Hydrologics Inc. conducted similar analyses for smolts and older juvenile fish passage flows (7.1 cfs) as those described above for adult fish (Appendix B, Podlech 2020). Streamflow exceeded 7.1 cfs on an average of 38 days per year upstream of the diversion, and on an average of 37 days downstream of the diversion during 2014-2017 WYs. WY 2016 was the only year during this timeframe in which the frequency of days exceeding the smolt passage flow upstream of the diversion (43 days) was higher than downstream of the diversion (39 days). In this particular year, the 4 days were the last days of the season when either gage exceeded 7.1 cfs for smolt passage. The difference in recorded streamflow between upstream and downstream of the diversion on these four days were 0.42 cfs or less (0.07, 0.4, 0.38, 0.42 cfs), and the recorded daily diversion amounts were 0.19 cfs on all days. Assuming the gages are equally accurate, this indicates that without the diversion, the 7.1 cfs recommended flows would still not have been met on 3 of these 4 days in the downstream reach. Based on the minor and temporary differences in flows between above and below the diversion, and considering the range of instrument accuracy, NMFS suspects emigrating smolts, or older juvenile fish, were still likely to successfully pass the most critical

[10] The discrepancies between the upstream and downstream gages indicate either slight gage error or range of accuracy.

riffle below the diversion during these four days. Smolts move at night, which coincides when diversion magnitudes are reduced due to lower demand (Alley 2018b; Podlech 2020).

Assuming these were representative conditions for a wide range of different WY types, NMFS concludes the continued operation of the diversion in accordance with the water right and bypass flow requirements is unlikely to appreciably affect migration success or survival of steelhead or coho salmon smolts and older juveniles, nor diminish the value or function of PBFs for designated critical habitats.

Age 0+ Juvenile Steelhead and Coho Salmon Passage. The proposed operation of the diversion has the potential to impact juvenile steelhead and coho salmon movements from and within the lower reach of Fall Creek. Per the existing water right, the minimum dry season bypass flow requirements vary depending on the WY type with 0.5 cfs for dry, and 1.0 cfs for normal and wet WY types. By March 1, the WY type designation on that date is used through the rest of the low-flow season (through October). To ensure suitable juvenile salmonid passage at critical riffles in the reach of Fall Creek below the diversion, Alley (2018b) recommended that water depths in the thalweg of riffles should be a minimum of 0.1 feet (1.2 inches), and there must be streamflow continuity through the 0.4 miles to the San Lorenzo River. For juvenile salmonid passage, Alley estimated a minimum flow of 1 cfs (Table 4).

The California Environmental Flows Framework (CEFF) provides ecological-flow criteria for streams throughout California. The framework uses reference hydrologic expectations to predict a set of functional flow metrics that quantify functional flows for each stream. The magnitude of the dry season flow is calculated as the 50th and 90th percentile of the flows ranging from the start of the dry season baseflow period until the start of the wet season. For Fall Creek downstream of the diversion, CEFF estimates for dry season baseflows in dry, normal, and wet years are 0.65, 0.86, and 1.15 cfs, respectively (Table 5).

Table 5. Summary of water right bypass streamflow criteria, and recommended streamflow from Alley (2018b) and CEFF for juvenile passage and protection of biological communities. Values are in cfs.

Year Type	1987 Water Right Bypass Flow Requirement	Critical Riffle Analysis (juvenile passage)	CEFF (median)
Dry	0.5	1.0	0.65
Normal / Wet	1.0	1.0	0.86 / 1.15

During the normal (2016) and wet (2017) years, streamflow in Fall Creek downstream of the diversion during the May through October period remained above 1.2 cfs and 2.5 cfs, respectively (Figure 3). These minimum flow rates exceeded all required and recommended streamflow values for fish passage and instream habitat function (Table 5). During the 2018 WY (dry year), daily mean streamflow remained at or above 1.0 cfs through the dry season and met the required bypass and recommended flows (Figure 3 and Table 5). Over the same period, in the critically dry year of 2014 and dry year of 2015, streamflow below the diversion declined to as low as 0.3 cfs in 2014, and 0.13 cfs in 2015 (Figure 4). These years represented year 3 and 4, of a multi-year drought, whereas 2018 followed a very wet 2017 WY. In both 2014 and 2015, streamflow below the diversion remained above 0.65 cfs into July, and 0.5 cfs through late July (Figure 4).

Alley (2018b) was unable to calibrate streamflow and depths across critical riffles during periods when depths were 0.1 feet. Instead, to estimate minimum flow thresholds that would be capable of providing passage for juvenile salmonids at these depths, they visually extended the trend line using only data points of the lowest two calibration flows. This produced the estimate of 1.0 cfs. However, during habitat assessments in fall 2015, Alley (2018b) noted that riffle depths and flow continuity at a streamflow of 0.32 cfs were sufficient for juvenile salmonid passage through lower Fall Creek down to the riffle at the creek mouth.

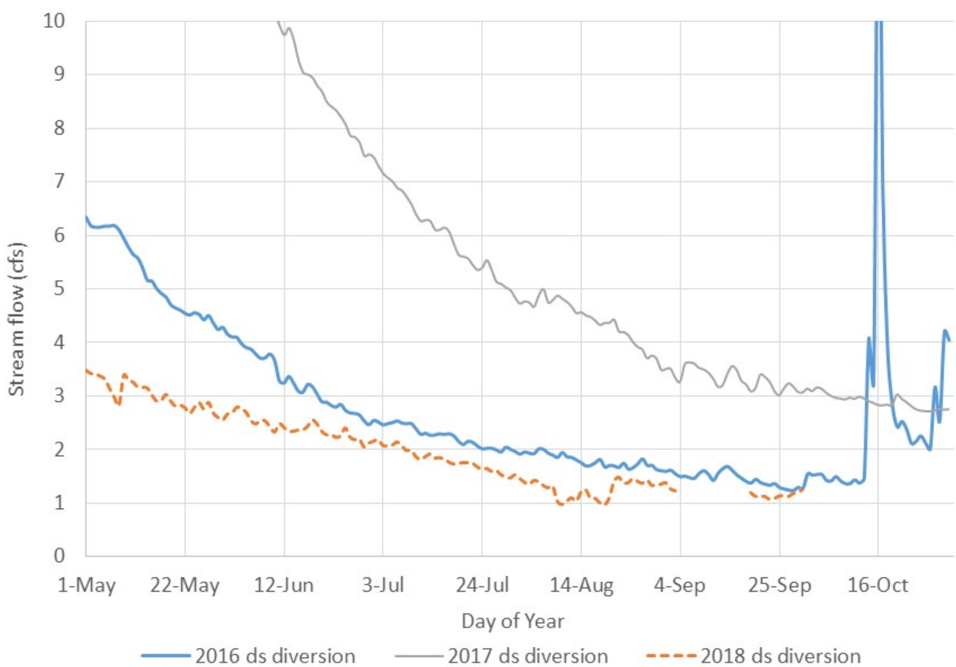

Figure 3. Daily mean streamflow in Fall Creek upstream (us) and downstream (ds) of the diversion between May 1 and October 31, 2016, 2017 and 2018.

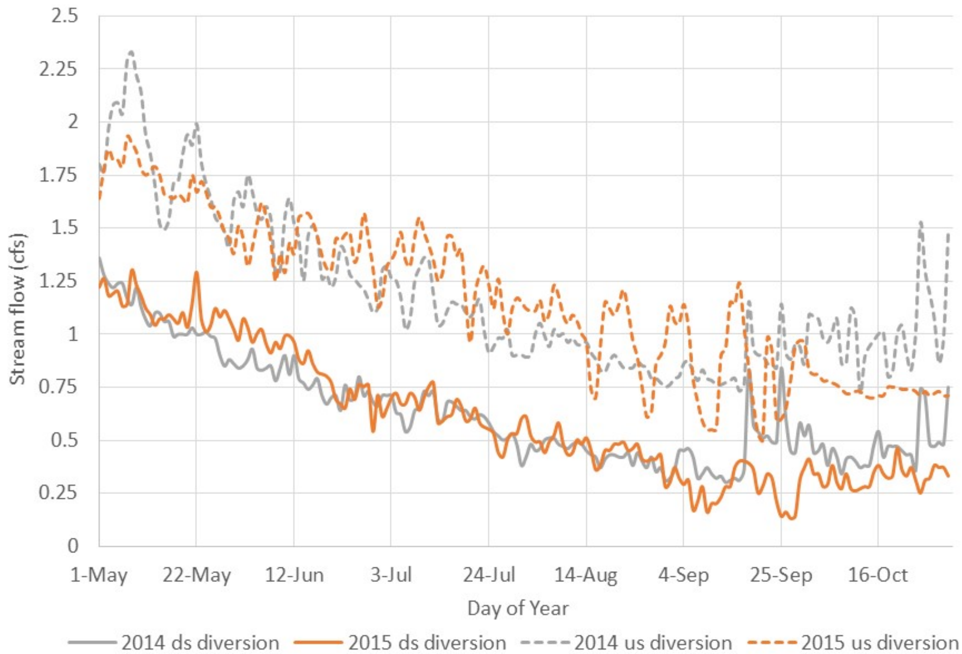

Figure 4. Daily mean streamflow in Fall Creek upstream (us) and downstream (ds) of the diversion between May 1 and October 31, 2014 and 2015.

Minimum passage requirements are based on typical fish sizes, or heights. The vast majority of the juvenile fish that rear in Fall Creek are YOY, and are less than 75 mm fork length (Alley 2018b). Fish of this size have a body height (dorsal to ventral) of approximately 0.75 inch or less. For example, Figure 5 shows an approximately 82 mm fork length juvenile steelhead from a similar stream type of the Santa Cruz Mountains, with a body height of 0.75 inches. Using the minimum depth criteria in the thalweg of critical riffles of 0.1 feet (1.2 inches), fish of this size (and smaller) would have nearly 0.5 inches of additional water depth above them, and therefore should be able to pass through the action area.

Figure 5. A juvenile steelhead (approximately 82 mm) from Bodfish Creek in the Santa Cruz Mountains with a maximum body depth of 0.75 inches. Photo: Joel Casagrande, NMFS, September 2019.

The movement of young, juvenile salmonids in streams occurs in late spring and early summer; movements decline in summer and fall when fish exhibit high site (habitat unit) fidelity (Alley 2018b; Sogard et al. 2009). The minimum flow for juvenile movements developed by Alley

(2018b) was for the period of April through June (Table 4), when juvenile salmonids distribute and move between habitats.

Considering the information discussed above, and assuming future operations evaluated in the biological opinion will be similar to the range of flows observed in 2014-2018, we expect young, juvenile steelhead and coho salmon will have sufficient depth and surface flow continuity to move through the lower reach of Fall Creek during the April-June period. During exceptionally dry years (e.g., consecutive dry years), the diversion is likely to restrict some movement within the channel later in the season (e.g., from pool to pool) for brief periods. Based on past streamflow observations (Figure 4) and considering the strong site fidelity of juvenile fish by July, these periods of restricted movement are expected to be temporary and only when flows are less than 0.2 cfs (Table 6). NMFS expects this will result in relatively temporary and minor impacts on fish movement but not to the extent that it would impact their fitness or survival. Additional monitoring of riffle depths and flow continuity is needed at lower flows (e.g., less than 0.3 cfs) to better ascertain fish passage potential.

2.5.7.2 Effects on Juvenile Salmonid Rearing Habitat and Abundance

In addition to potential impacts on fish passage/movements, the operation of the diversion may also affect the rearing habitat space and fish abundance downstream of the diversion. In general, surface water diversions reduce the amount of water in a stream, which results in some loss of habitat space. As described above, in normal (2016), wet (2017), and dry years (2018) streamflow in Fall Creek below the diversion remained above 1.2, 2.5, and 1.0 cfs, respectively, through the May-October period. These minimum flow rates exceed the required bypass flows (0.5 cfs), and the recommended flow criteria for fish passage (1.0 cfs) and instream ecological function (0.65 cfs) (Table 5).

Over the same period of the dry 2014 and 2015 WYs, streamflow below the diversion declined to as low as 0.3 cfs (2014) and 0.13 cfs (2015) (Figure 4). From mid-July to November 2014, streamflow in Fall Creek downstream of the diversion remained between 0.3 and 0.5 cfs. In 2015, streamflow downstream of the diversion remained less than 0.5 cfs continuously from mid-August through October, and with the exception of brief periods in early and late September of 2015, streamflow remained above 0.25 cfs through October.

Field observations of riffles and streamflow continuity throughout the lower 0.4 miles during these lowest flow periods of 2014 and 2015 were not made, and therefore NMFS cannot determine if surface flow continuity was temporarily broken during these periods. The disconnection of streamflow would leave pools isolated with groundwater as the only potential source of inflow. Such conditions would have the greatest impact on rearing habitat quantity and quality and fish survival. Based on the incised bedrock channel morphology of Fall Creek in this reach, which has a shallow alluvium layer, surface flow loss to groundwater percolation is insignificant, if any at all. Therefore, we expect that while the diversion reduced the amount of streamflow connecting pools through this reach, flow rates as low as 0.13 cfs should have maintained full pools and surface flow connectivity between them.

Such reductions in streamflow are expected to reduce the wetted extent of habitat in Fall Creek. However, a magnitude of streamflow reduction does not equate to an equal magnitude of habitat loss. For example, Alley (2018b) found that mean and maximum pool, riffle and run depths were similar in 2014 and 2015, despite flows being more than twice as much in 2014 than 2015 (Table 6). On August 7, 2014, riffle depths in the reach below the diversion averaged 0.3 ft (4 inches) at a flow of 0.51 cfs, and at flows of 0.37 and 0.21 cfs, riffles depths averaged 0.25 ft (3 inches) (Table 6). These depths all exceeded the 0.1 ft (1.2 inch) recommendation.

While pools remain full even at lower flows, the depth and velocity of water connecting pools is reduced, and the wetted extent across the channel is likely to shrink. Such conditions would force juvenile salmonids to rely more exclusively on pool habitats and may result in temporary periods of increased competition. If surface inflow to pools ceases altogether, then dissolved oxygen in the pools can become limited and fish health and survival are at a greater risk of being adversely impacted. Recent monitoring during drought conditions found that juvenile salmonids are capable of persisting in pools through stressful conditions with only a small amount of surface inflow. Dolman et al. (2019) found high survival of juvenile salmonids (>90 percent) in pools of Green Valley Creek (a tributary to the Russian River) with average daily inflows as low as 0.05 cfs.

Table 6. Streamflow and mean and maximum riffle depths in Fall Creek downstream of the diversion in summer 2014 and 2015.

Date	Daily Mean Stream flow (gage) cfs	Instantaneous Stream flow (measured) cfs	Mean riffle depths ft	Maximum riffle depth ft
7-Aug-14	0.51		0.3	0.4
27-Aug-14	0.37		0.25	0.6
17-Aug-15	0.38	0.41		
7-Sep-15	0.21		0.25	NA

Considering the depth criteria for juvenile movement of 0.1 ft (1.2 inches) and the measured riffle depths in 2014 and 2015 described above, juvenile salmonids were likely still able to move throughout the wetted channel at flows as low as 0.21 cfs. Using the August 7, 2014 streamflow and riffle depths and comparing those with the September 7, 2015 streamflow and riffle depths, we can infer there was an approximate 17 percent reduction in habitat. Given the available information, NMFS expects brief periods (one week or less) of exceptionally low flow (e.g. 0.13 cfs in 2015) downstream of the diversion will temporarily restrict movement within the 0.4 miles of rearing habitat. Although this will cause some stress from crowding, NMFS does not expect this will result in injury or mortality of juvenile steelhead in this reach due to the short duration of these events. Future monitoring of habitats (depths and widths) across a wider range of streamflow conditions will likely provide a better understanding of the relationship between streamflow and habitat availability.

Reduced streamflow may also affect juvenile salmonid growth rates through changes in water temperatures, reduced invertebrate drift into pool habitats, and increased competition from crowding. The growth of juvenile salmonids is heavily influenced by water temperature (Myrick and Cech 2005), which is influenced by the amount of shade over the stream and streamflow volume. Fall Creek is a heavily shaded stream with persistently cool temperatures. Alley (2018a) measured water temperatures in Fall Creek using continuous data loggers upstream and downstream of the diversion from WY 2014 through WY 2017. Temperatures were assessed using maximum weekly average temperature (MWAT) threshold criteria of 20°C and 16.7°C to evaluate rearing habitat suitability for juvenile steelhead and coho salmon, respectively. Water temperatures below the diversion point do not appear to be negatively affected by the diversion. In all four years, the water temperatures were consistently less than the thresholds for juvenile steelhead (20°C) upstream and downstream of the diversion. The criteria for coho salmon was almost always met at both locations except for brief periods downstream of the diversion in 2015 (1.5 weeks), and 2017 (2 days). Even these brief exceedances never exceeded 17.0°C. Lusardi et al. (2020) found that juvenile coho salmon absolute growth rates peaked at a mean daily average water temperature of 16.6°C, and an associated maximum weekly maximum temperature of 21.1°C. Under these thermal conditions, they found juvenile coho salmon growth was six-fold that of fish that reared in cooler temperatures.

The growth of juvenile salmonids also varies throughout the year. Studies from regional streams have shown that growth of juvenile salmonids in small, step-pool streams of the Santa Cruz Mountains that are well shaded and cool, declines substantially after spring (Smith 1982; Sogard et al. 2009). The juvenile steelhead population in Fall Creek at the end of the dry season is consistently dominated by small YOY (< 80 mm fork length) regardless of the water year type. Alley (2018b) attributed the low growth to the consistently cool temperatures, heavy shading, and degraded substrate quality. Steelhead YOY sizes in Fall Creek in late summer or fall are similar to those observed in other streams of the Santa Cruz Mountains (Hayes et al. 2008; Sogard et al. 2009; Casagrande 2020; Smith 2020; Alley 2021).

Juvenile salmonids rely on a mixture of terrestrial and aquatic invertebrates (Rundio and Lindley 2008; Grunblatt et al. 2019). This can include terrestrial-derived invertebrates that fall or fly into streams, and the larval forms that live within stream substrate and become available as drift or directly from the substrate (Merritt and Cummings 1996). Studies have shown that terrestrial invertebrate prey typically become more abundant as the summer dry season progresses and therefore become an increasingly important (50-90 percent) of the fish diet during the dry season (Merritt and Cummings 1996; Sweka and Hartman 2008).

Although growth is generally poor in Fall Creek during the dry season regardless of streamflow Alley 2018b), the reduction of streamflow by as much as 60 percent at times limits invertebrate drift. The full implications of this partial reduction of food delivery to juvenile salmonids is unknown. As described above, it may not have a significant impact as invertebrate drift quantity naturally declines in summer and terrestrial invertebrate drop becomes a more important component of the fish diet. Based on the information discussed above and the similar fish lengths at the end of the growing season across years and regional streams, NMFS concludes the impacts of reduced flows later in summer on juvenile salmonid growth in dry years is unlikely to reach levels that would appreciably impact their survival or fitness within the action area.

As described above in Section 2.4.3, the abundance of juvenile steelhead has been sampled annually in Fall Creek upstream of the diversion since 2008 (and in some years before), and downstream of the diversion since 2014 (Figure 2). Between 2014 and 2020, juvenile steelhead densities upstream of the diversion averaged 35 fish per 100 feet, and 38 fish per 100 feet downstream of the diversion. In four of seven years with paired sampling, juvenile steelhead abundance has been greater downstream of the diversion compared to upstream (Figure 6).

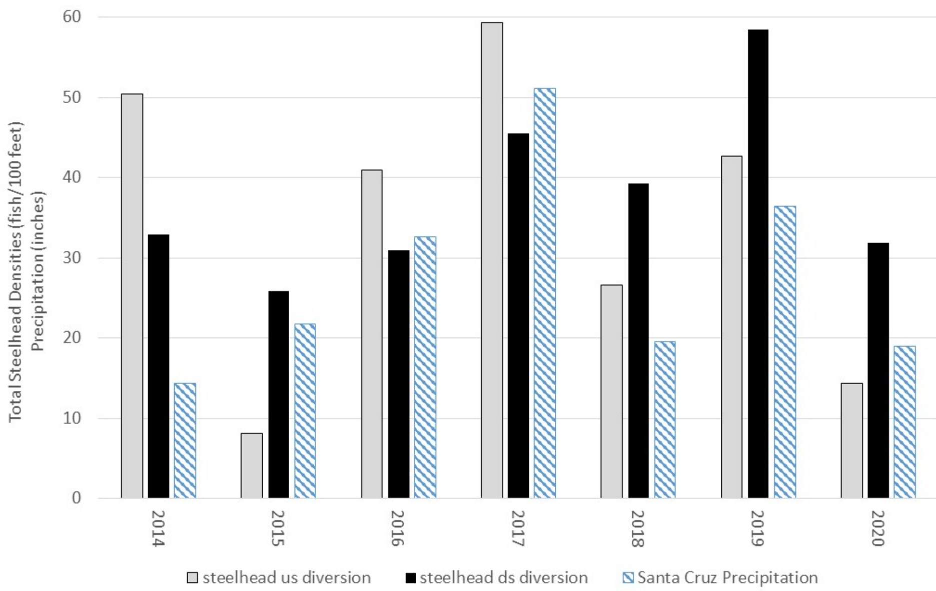

Figure 6. Juvenile steelhead abundance upstream (us) and downstream (ds) of the diversion in Fall Creek collected in the fall by Don Alley, and annual precipitation in the City of Santa Cruz (Department of Water Resources).

Juvenile steelhead abundance in Fall Creek during late summer or fall (September to October) appears strongly correlated with the preceding winter's (January to March) precipitation totals, with higher abundances following wetter winters and lower abundances in drier winters (Figure 6). The timing of storms during the winter season is also important as it influences adult escapement. Figures 1 through 4 in Appendix B (Podlech 2020) show the annual hydrographs for 2014-2017 and both the frequency and duration of adult passage access to Fall Creek (based on the 17.1 cfs criteria). Although the 2013-2014 winter was the driest of the 2012-2016 drought years, the few storms that did occur that year were in February, which is the peak of the adult steelhead upstream migration period. Conversely, the 2014-2015 winter was slightly wetter than the previous, however the few storms capable of providing passage for adult steelhead into Fall Creek occurred in late November and mid-December, which is early for typical upstream migration in the Santa Cruz Mountains. Consequently, in 2015, the abundance of juvenile steelhead in Fall Creek upstream and downstream of the diversion was the lowest observed to date (Figure 2). Furthermore, the abundance of juvenile steelhead downstream of the diversion in

2016, a normal year with dry season flows consistently above the required or recommended thresholds, was not that much greater than 2015, and slightly less than 2014 both upstream and downstream of the diversion. These observations suggest low juvenile steelhead abundances in 2015 and 2016 were related to low adult escapement to the entire San Lorenzo River watershed, which was considerably lower in 2015 and the previous two years (Table 3). Once the drought ended, and opportunities for adult escapement increased, juvenile steelhead abundances (2017-2019) rebounded and were again at or above average at both sites. Based on the available data, NMFS also concludes the diversion is not expected to affect juvenile fish abundance in the reach downstream of the diversion.

Finally, the streamflow gage downstream of the diversion apparently under-reported bypass flows prior to 2018, rendering our analysis of SLVWD's operations during this timeframe relatively conservative. During the 2018 debris cleaning activities at the ladder, dewatering of the ladder chambers revealed there was significant seepage between the concrete footing of the ladder and the bedrock channel. This seepage was not captured by the downstream gage and therefore actual bypass flows in the reach of Fall Creek downstream of the diversion were under-reported. Balance Hydrologics, Inc. has since upgraded this gage to address the potential inaccuracies (M. Podlech, personal communication, April 2021). The SLVWD has committed to continuing streamflow monitoring in Fall Creek and expanding habitat assessments throughout the dry season. These measurements will be used in conjunction with ongoing juvenile salmonid monitoring at both upstream and downstream sites in Fall Creek, and will provide a better understanding of the impacts the diversion may have on critical habitat for juvenile salmonids, particularly in dry years. The habitat assessments will commence in summer 2021.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

NMFS does not anticipate any cumulative effects in the action area other than those ongoing actions already described in the Environmental Baseline above. Given current baseline conditions and trends, NMFS does not expect to see significant changes in habitat conditions in the near future due to existing development and use of water in the watershed. NMFS assumes the rate of such development and water use would be similar to that observed in the last decade.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

The Project action area is located in Fall Creek, a perennial tributary to the San Lorenzo River. The San Lorenzo River supports threatened CCC steelhead. NMFS identified the San Lorenzo River as a historically independent population for the CCC steelhead DPS as it is the largest population and watershed within the Santa Cruz Mountains Diversity Stratum (NMFS 2016b). The San Lorenzo River watershed is also known to support endangered CCC coho salmon. NMFS identified the San Lorenzo River as one of two historically independent CCC coho salmon populations within the diversity stratum (NMFS 2012). Fall Creek is designated critical habitat for both the CCC steelhead DPS and CCC coho salmon ESU.

CCC steelhead and CCC coho salmon have declined from their historic abundances due to the widespread degradation and loss of historic habitats caused by factors including hydrologic modifications (reservoir storage, surface diversions, and groundwater pumping), land use change (urbanization, timber harvest, agriculture, and mining), construction of dams and other migration impediments, channelization and disconnection from floodplains, and the introduction of non-native and invasive species. Coho salmon populations within the diversity stratum have declined substantially over the past several decades and now are only occasionally found in the San Lorenzo River basin—usually the result of straying from hatchery releases. Juvenile coho salmon were last observed in Fall Creek in 1981.

The Project includes the replacement and improvement of an existing fish ladder, the relocation and improvement of an existing surface water diversion intake within the ladder, and the future maintenance and operation of these facilities following completion. The Project will require temporary dewatering of approximately 200 feet of Fall Creek (mostly in the existing ladder), fish capture and relocation, and grading and other disturbances during construction. Future maintenance is expected to occur approximately every 2 to 3 years and will include temporary dewatering of approximately 200 feet of creek, sediment removal from the ladder, and other necessary repairs to the weirs and diversion intake structures. Finally, operations will include surface water diversions from Fall Creek in accordance with their existing water right and bypass flow requirements. Construction will occur during the dry season (June 15-October 15) of either 2021 or 2022. We expect juvenile steelhead will be present throughout the action area. The consistent presence of juvenile coho salmon in the action area is unlikely. However, with continued efforts at habitat and coho salmon population restoration in the Santa Cruz Mountains by the Southern Coho Salmon Captive Broodstock Program, there is a reasonable likelihood of adults returning to Fall Creek and successfully spawning, and therefore NMFS concludes a small number of individuals are likely to be present in the action area at some times during project activities.

2.7.1 Summary of Effects to CCC steelhead and CCC coho salmon

In this opinion we analyze the effects of the proposed action during 1 year of construction and operations, and subsequent years of operations and maintenance activities. NMFS identified the following components of the proposed action that may result in effects to CCC steelhead and CCC coho salmon: fish collection and relocation, dewatering, temporary increases in suspended sediment and other construction-related contaminants, fish passage, and streamflow modification from diversions. Of these, fish collection and relocation, and dewatering are likely to result in injury, mortality, or harm of juvenile CCC steelhead and CCC coho salmon. For construction and maintenance, NMFS estimates up to 200 juvenile CCC steelhead and 10 juvenile coho salmon may be present in the dewatered area.

Anticipated injury or mortality from capture and relocation is expected to be three percent (or less) of the fish present, and injury or mortality expected from dewatering is expected to be two percent (or less) of the fish present prior to relocation and dewatering (combined injury or mortality not to exceed five percent). Therefore, NMFS expects no more than 10 juvenile steelhead would be injured or killed by fish capture/relocation/dewatering at the project site during construction and during each large-scale maintenance event in years after construction is complete. Similarly, because no more than 10 juvenile coho salmon are expected to be present during construction or maintenance activities, NMFS expects no more than 2 juvenile coho salmon will be injured or killed by fish capture, relocation, and dewatering.

In addition to the adverse effects described above, we also considered the potential impacts of increased sedimentation and turbidity and other hazardous contaminants during construction, modifications to the channel to facilitate the larger ladder structure, and surface water diversions. The implementation of proposed minimization measures is expected to render the potential for exposure to water quality impairment as improbable. Although the new fish ladder will slightly increase the amount of hardscape in the channel, this level of conversion is not expected to result in reductions in fitness of individual salmonids within the action area and instead the new ladder will facilitate improved fish passage for salmonids of all life stages through the action area.

We expect the continued operation of the surface water diversion will result in similar instream conditions as those observed in recent decades. The small and steady diversion amount during winter and spring does not appear to affect the opportunities for adult or smolt migration through the action area. The diversion of up to 0.5 cfs will cause a minor reduction in habitat space during the dry season, particularly during exceptional drought conditions.

Based on the available data, including the annual juvenile steelhead abundance during fall, opportunities for adult escapement into Fall Creek during the preceding winter, and riffle crest depth measurements during the dry season, the diversion does not appear to impact steelhead or coho salmon numbers in the action area. Moreover, the data on fall juvenile abundance over time shows that the population is somewhat resilient and able to rebound quickly after extreme drought events. NMFS does not expect any of the aforementioned effects to occur simultaneously with other effects in any significant way. Due to the relatively large number of juveniles produced by each spawning pair, steelhead and coho salmon spawning in the Fall Creek watershed in future years are likely to produce enough juveniles to replace the few that are likely to be lost in the action area due to the effects of the proposed action (fish collection, relocation, and temporary dewatering for construction or maintenance). Therefore, we do not expect the proposed project to affect the persistence or recovery of the San Lorenzo River population of steelhead or coho salmon.

2.7.2 Summary of Effects on Critical Habitats

Fall Creek contains critical habitat for the CCC steelhead DPS and CCC coho salmon ESU. In our adverse modification analysis, we consider the condition of critical habitat, the potential effects of the Project on critical habitat, and whether or not those effects are expected to diminish the value of critical habitat for the conservation of CCC steelhead or CCC coho salmon.

Critical habitat for the CCC steelhead DPS and CCC coho salmon ESU has been impaired. While conditions vary, critical habitat has been impaired by habitat loss, alteration and fragmentation, surface and groundwater extraction, land use conversion, and estuarine habitat loss. Except for estuarine habitat loss, these factors also affect CCC steelhead and CCC coho salmon critical habitat in Fall Creek, which have been impaired by rural developments, water diversions, and historic forestry and other land use practices. Both watershed-wide factors and action area-specific factors affect critical habitat in the action area leading to reduced habitat complexity and accessibility, poor substrate quality for spawning, and limited juvenile rearing habitat.

The Project will result in both temporary and permanent impacts to critical habitat. Temporary impacts will occur during construction and maintenance activities, while permanent impacts will be the result of channel modification for the improved fish ladder and continued streamflow diversions.

During dewatering activities, up to 200 feet of rearing habitat (75 feet within the existing ladder) that supports juvenile salmonid development will be unavailable for up to 10 weeks during the duration of channel dewatering. This will result in the temporary loss of benthic macroinvertebrates (juvenile salmonid prey) in the dewatered reach. In addition, because the temporary bypass flow structure used for dewatering will be screened to keep fish from entering the bypass pipe, the summertime movement of juveniles throughout the steam will not be allowed during this period. However, as described above, the movement of juveniles in cool water streams is minimal during summer months, so we expect impacts to the availability of critical habitat during construction to be minimal.

The new improvements to the ladder will result in the conversion of less than 25 feet of natural channel bed and banks to concrete. At this location, Fall Creek is a deeply entrenched channel with near vertical banks consisting of primarily of bedrock. The two new weir pools will replace riffle and shallow pool habitat with deep ladder pools. At depths up to 4 feet, these pools will be some of the deepest available in this reach of Fall Creek, and as previous observations have noted, the new pools are expected to be heavily utilized by juvenile salmonids for rearing. Due to the steep bedrock banks, stream-side and overhanging vegetation is limited. A 24-inch tree stump will be removed from the bank, and a small number of young trees (less than 4 inches DBH) will be removed. The removal of vegetation will be minimized to the greatest extent possible, and all disturbed areas, not converted to concrete for the expanded fish ladder, will be replanted with similar native, riparian species. The improved ladder will also enhance fish passage conditions for both adult and juvenile life stages of steelhead and coho salmon. Specifically, the weir jump heights will be reduced from as much as 18 to 24 inches, to a consistent 12 inches. The deeper weir pools (2 to 4 feet) will facilitate better leaping conditions and fish passage success through the ladder.

Maintenance activities may require channel dewatering similar to the construction extents (up to 200 feet). Dewatering for maintenance may be necessary as frequently as every 2 to 3 years to perform repairs of the fish ladder and diversion intake structure, and to remove accumulated sediment and debris as needed.

The SLVWD proposes to operate their diversion in accordance with their water right and bypass flow requirements. We expect the diversion operations will be similar to those during the 2014-2018 monitoring period, which included two consecutive dry years, a normal year, a wet year, followed by a dry year. The monitoring data revealed that during normal, wet, and single dry water years (e.g., 2018), SLVWD was able to meet bypass flow requirements as well as minimum recommended flows for migration and instream movement of juvenile and adult salmonids. However, in dry years like 2014 and 2015, the SLVWD may not be able to sustain these bypass flow requirements consistently. In both years, the diversion reduced flows to less than 0.5 cfs in the latter half of the dry season, and in 2015 streamflow was reduced below 0.25 cfs for brief periods as diversion rates approached 0.5 cfs. Diversions of this magnitude do not appear to impact water temperatures in Fall Creek. Diversions of this magnitude will, however, temporarily reduce rearing habitat space for juvenile steelhead and coho salmon during low flows (i.e., flows approximately 1 cfs or less). Due to the bedrock channel morphology in Fall Creek, streamflow loss to percolation will be extremely low. Because of this, streamflow in the 0.4 miles to the San Lorenzo River is expected to remain connected, especially during the early half of the dry season. Although the diversion will temporarily reduce quantity of available habitat for juvenile steelhead and coho salmon in the affected reach, we do not expect this level of reduction will diminish the value of critical habitat as a whole for the conservation of the species.

Finally, the SLVWD will continue its commitment to monitoring of juvenile salmonids in Fall Creek and will expand and refine its streamflow and habitat monitoring activities. These data will be used evaluate and track changes in habitat extent and quality for juvenile salmonids in response to the diversion operations.

2.7.3 Climate Change

Future climate change could affect CCC steelhead and CCC coho salmon and their designated critical habitats within the action area. Some potential consequences of climate change in the Monterey Bay region are increases in both air and water temperatures, and changes in the timing and magnitude of storms, their runoff, and dry season streamflow. These projections further highlight the importance of providing suitable streamflow conditions for fish passage, spawning and rearing in the streams of the CCC steelhead DPS and CCC coho salmon ESU.

Fall Creek is a predominantly southeast facing drainage with steep, entrenched channels that are naturally well-shaded. These drainage characteristics and the karst geology will buffer against the potential climate-driven impacts on streamflow and water temperatures. Over time, climate change may alter the vegetation communities of the central California coast, including the coast redwood forest that dominates the action area. Through the end of this century, we expect this drainage will remain forested, which will continue to buffer against potential changes in water temperature. Furthermore, the improvements to the fish ladder will facilitate easier access for both juvenile and adult steelhead and coho salmon to and from reaches of Fall Creek upstream of the action area. This improved access, especially for juvenile fish, will enhance access to thermal refugia in the upper reaches of Fall Creek.

Finally, the SLVWD will continue to operate their diversion in Fall Creek in accordance with their water right. This would include their adherence to bypass flow requirements intended to protect fish and wildlife and their instream habitats. If streamflow yield were to decline in response to climate change, this could reduce the frequency and duration of suitable flows for adult and smolt passage. The relatively low maximum diversion rate (0.5 cfs) coupled with low water demand during the winter months is not expected to appreciably impact streamflow or the ability for adult or smolt salmonids to move through Fall Creek. Finally, if lower streamflow conditions prevail in the future due to climate change, the minimum bypass flow requirements would remain in place and continue to protect rearing salmonids during the dry season.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the CCC steelhead DPS, nor destroy or adversely modify its designated critical habitat.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence CCC coho salmon, nor destroy or adversely modify its designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that take is reasonably certain to occur. Table 7 summarizes the maximum anticipated take by Project activity, location, and frequency. We analyzed the effects of the Project, including construction, maintenance, and operation activities. We assume maintenance activities that will require dewatering will occur as frequently as every two years. During years with either construction or maintenance activities, up to 200 juvenile steelhead are expected to be present, of which 10 may be injured or killed from capture and dewatering activities. Although unlikely to be consistently present in the action area, a small number of juvenile coho salmon (10) are expected to be present in the action area in any given year, of which we expect no more than 2 will be injured or killed from capture and dewatering activities. The expected amount of incidental take will be exceeded if the amount of fish collected, killed, or injured exceeds the amounts listed in Table 7.

Table 7. Summary of incidental take of juvenile steelhead and coho salmon during construction and maintenance activities.

Activity	Frequency	Steelhead		Coho salmon	
		Expected abundance[1]	Unintentional injury or mortality[2]	Expected abundance[1]	Unintentional injury or mortality[2]
Construction					
fish capture/relocation	1	200	6	10	1
dewatering	1	-	4	-	1
Maintenance					
fish capture/relocation	once every two years	200	6	10	1
dewatering	once every two years	-	4	-	1

[1] This is the expected abundance during each dewatering and fish relocation event. The number of these events is given in the frequency column.
[2] Individual fish that are unintentionally injured or killed are a portion of the fish incidentally taken.

In the biological opinion, we describe the anticipated effects of the diversion operations on salmonid migration and rearing. Based on the past performance of the diversion and the response of the affected reach of Fall Creek, the diversion does not appear to appreciably affect adult or smolt passage success. NMFS also concludes the diversion will not result in take of rearing juvenile steelhead or coho salmon during the dry season.

However, if operation of the diversion results in flow conditions not considered in the biological opinion, e.g., lower flows, adverse effects may increase and take may occur and reinitiation of consultation may be needed. See Section 2.11 (Reinitiation of Consultation) below.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of juvenile CCC steelhead and juvenile CCC coho salmon:

- Undertake measures to ensure that injury and mortality to salmonids resulting from fish capture and relocation and dewatering activities is low;
- Undertake measures to minimize harm to salmonids from the project through degradation of aquatic habitat; and
- Prepare and submit plans and reports regarding fish capture and relocation, dewatering, construction and maintenance activities, and habitat and streamflow monitoring.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Corps, SLVWD or any contractor must comply with them in order to implement the RPMs (50 CFR 402.14). Corps, SLVWD or any contractor has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:
    a. Corps, SLVWD, or the contractor will allow any NMFS employee(s), or any other person designated by NMFS, to accompany field personnel to visit the project sites during activities described in this opinion.
    b. Corps, SLVWD, or the contractor will retain qualitied biologists with expertise in the area of anadromous salmonid biology, including handling, collecting, and relocating salmonids; salmonid/habitat relationships; and biological monitoring of salmonids. All fisheries biologists working on this project will be qualified to conduct fish collections in a manner that minimizes all potential risks to ESA-listed salmonids. Electrofishing, if used, shall be performed by a qualified biologist and conducted according to the NOAA's electrofishing guidelines

(NMFS 2000). See: http://www.nwr.noaa.gov/ESA-Salmon-Regulations-Permits/4d Rules/upload/electro2000.pdf.

c. Corps, SLVWD, or the contractor will ensure that a biologist monitors the construction sites during placement and removal of cofferdams and channel diversions to ensure that any adverse effects to salmonids are minimized. A biologist will be on site during all dewatering events to capture, handle, and safely relocate salmonids to an appropriate location. The biologist will notify NMFS staff at joel.casagrande@noaa.gov, or at 707-575-6016, one week prior to capture activities in order to provide an opportunity for NMFS staff to observe the activities. During fish relocation activities the fisheries biologist shall contact NMFS staff at the above number, if injury or mortality of federally listed salmonids exceeds 5 percent of the total for each species collected at each project site, at which time NMFS will stipulate measures to reduce the take of salmonids.

d. Salmonids will be handled with extreme care and kept in water to the maximum extent possible during rescue activities. All captured fish will be kept in cool, shaded, aerated water protected from excessive noise, jostling, or overcrowding any time they are not in the stream, and fish will not be removed from this water except when released. To avoid predation, the biologist will have at least two containers and segregate young-of-year from larger age classes and other potential aquatic predators. Captured salmonids will be relocated, as soon as possible, to a suitable instream location (pre-approved by NMFS – see 3a below) in which suitable habitat conditions are present to allow for adequate survival of transported fish and fish already present.

e. If any steelhead or salmon are found dead or injured, the biological monitor will contact NMFS staff at joel.casagrande@noaa.gov or at 707-575-6016. The purpose of the contact is to review the activities resulting in take, determine if additional protective measures are required, and ensure appropriate collection and transfer of salmonid mortalities and tissue samples. All salmonid mortalities will be retained. Tissue samples are to be acquired from each mortality per the methods identified in the NMFS Southwest Fisheries Science Center Genetic Repository protocols (contact the above NMFS office at the phone number provided) and sent to: NOAA Coastal California Genetic Repository, Southwest Fisheries Science Center, 110 McAllister Way, Santa Cruz, CA 95060.

f. Non-native fish that are captured during fish relocation activities shall not be relocated to anadromous fish streams, or areas where they could access anadromous fish habitat.

2. The following terms and conditions implement reasonable and prudent measure 2:

   a. Corps, SLVWD, or the contractor will allow any NMFS employee(s) or any other person(s) designated by NMFS to accompany field personnel to visit the project site during activities described in this opinion.

   b. To ensure that the Project is built as designed and contractors adhere to construction best management practices, SLVWD will ensure monitoring will be performed during construction by qualified individuals. Monitors will be knowledgeable of the Project designs, construction minimization measures, and the needs of native fish, including steelhead and coho salmon. Monitoring will be performed daily. The monitor(s) will work in close coordination with Project management personnel, the Project design team, and the construction crew to ensure that the Project is built as designed.

c. Construction equipment used within the river channel will be checked each day prior to work within the creek channel (top of bank to top of bank).

d. SLVWD must ensure their streamflow and diversion monitoring gages record accurate accounts of streamflow and diversion rates. Any instrument errors or other issues (e.g., seepage around the gage) that would affect the accuracy of the reported flow rates shall be resolved as soon as possible.

3. The following terms and conditions implement reasonable and prudent measure 3:

   a. Fish Capture and Dewatering Plans – The Corps or SLVWD must submit a fish capture/relocation and channel dewatering plan to NMFS for review, including but not limited to suitable instream locations where any captured salmonids will be relocated in which suitable habitat conditions are present to allow for adequate survival of transported fish and fish already present. The plan shall be submitted electronically to NMFS biologist Joel Casagrande at joel.casagrande@noaa.gov at least 30 days prior to the planned start of these activities.

   b. Annual Reporting – The Corps or SLVWD must prepare and submit annual reports to NMFS for Project activities as outlined below. The reports must be submitted electronically to NMFS biologist Joel Casagrande at joel.casagrande@noaa.gov by January 31 the following year. Reports prepared for compliance with other agency requirements that contain the information requested below would be acceptable.

   The report must contain, at minimum, the following information:

      i. Construction and Maintenance related activities – The report(s) must include the dates construction began and was completed; a discussion of any unanticipated effects or unanticipated levels of effects on salmonids, including a description of any and all measures taken to minimize those unanticipated effects and a statement as to whether or not the unanticipated effects had any effect on ESA-listed fish; the number of salmonids killed or injured during the project action; and photographs taken before, during, and after the activity from photo reference points.

      ii. Fish relocation – The report(s) must include a description of the location from which fish were removed and the release site(s) including photographs; the date and time of the relocation effort; a description of the equipment and methods used to collect, hold, and transport salmonids; the number of fish relocated by species; the number of fish injured or killed by species and a brief narrative of the circumstances surrounding ESA-listed fish injuries or mortalities; and a description of any problems which may have arisen during the relocation activities and a statement as to whether or not the activities had any unforeseen effects.

iii. Habitat and Streamflow Monitoring – The report(s) must include a description of the period of record, data types collected, summary of results, summary of any unforeseen issues and steps taken to address these issues, and reference photos of habitat and streamflow conditions throughout the reporting period. In addition, the report(s) must include a description whether streamflow or habitat monitoring reveals that the conditions described in Section 2.11 below have occurred.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02). NMFS has no conservation recommendations as this time.

2.11 Reinitiation of Consultation

This concludes formal consultation for the Fall Creek Fish Ladder Improvement Project.

As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

For example, reinitiation of consultation may be necessary if:

Streamflow or habitat monitoring reveals that the operation of the diversion causes any of the following conditions:

- Streamflow in Fall Creek downstream of the diversion is less than 17.1 cfs for adult passage (December 15 – April 15), and 7.1 cfs for smolt passage (March 15 to end of June)[11]; or
- Streamflow at any riffle in Fall Creek downstream of the diversion is less than 0.1 feet (1.2 inches) deep across 10 percent of the wetted width (April 15 to June 30); or

[11] In the Effects of the Action section, we determined that the diversion apparently contributed to brief and minor instances when streamflow was less than these criteria for adult (17.1 cfs) and smolt (7.1 cfs) passage. Depending on the future magnitude and duration of any potential instances when operation of the diversion causes streamflow less than these criteria, in conjunction with the limits of streamflow gage accuracy, reinitiation may be required.

- Surface flow in Fall Creek downstream of the diversion becomes disconnected.

Similarly, increased adverse effects and take may occur if the diversion continues to operate under the following conditions:

- Streamflow at any riffle in Fall Creek downstream of the diversion is less than 0.1 feet (1.2 inches) deep across 10 percent of the wetted width; or
- Surface flow in Fall Creek downstream of the diversion is disconnected with the San Lorenzo River.

3 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

This analysis is based, in part, on the EFH assessment provided by the Corps (Podlech 2020) and descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

EFH managed under the Pacific Coast Salmon FMP (PFMC 2014) would be adversely affected by the Project. The Project action area is located in a freshwater area that supports spawning and thermal refugia Habitat Areas of Particular Concern (HAPCs) for coho salmon managed within the Pacific Coast Salmon FMP (PFMC 2014).

3.2 Adverse Effects on Essential Fish Habitat

NMFS determined the Project would adversely affect EFH for Pacific Coast Salmon species (coho salmon). The potential adverse effects of the Project on EFH have been described in the preceding biological opinion and include degraded water quality, benthic disturbance, reduction in streamflow, and loss of riparian vegetation. As described in the biological opinion above, degraded water quality, benthic disturbance, and loss of riparian vegetation effects are anticipated to be temporary and minor. Permanent adverse impacts will include minor reductions in streamflow caused by the operation of the diversion, and the conversion of less than 25 linear feet of natural stream channel to concrete as part of the fish ladder improvements.

3.3 Essential Fish Habitat Conservation Recommendations

Based on information developed in our effects analysis (see preceding biological opinion), NMFS has determined that the proposed action would adversely affect EFH for CCC coho salmon, which are managed under the Pacific Salmon FMP. Although adverse effects are anticipated as a result of the Project, the proposed minimization and avoidance measures, and best management practices described in the accompanying biological opinion are sufficient to avoid, minimize, and/or mitigate for the anticipated effects. Therefore, no additional EFH Conservation Recommendations are necessary at this time that would otherwise offset the adverse effects to EFH.

3.4 Supplemental Consultation

The Corps must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)). This concludes the MSA portion of this consultation.

4 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the Corps. Other interested users could include SLVWD, CDFW, City of Santa Cruz, and other local stakeholders. Individual copies of this opinion were provided to the Corps and SLVWD. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5 REFERENCES

Abdul-Aziz, O.I., N.J. Mantua, and K.W. Myers. 2011. Potential climate change impacts on thermal habitats of Pacific salmon (*Oncorhynchus spp.)* in the North Pacific Ocean and adjacent seas. Canadian Journal of Fisheries and Aquatic Sciences 68(9):1660-1680.

Adams, P.B., M.J. Bowers, H.E. Fish, T.E. Laidig, and K.R. Silberberg. 1999. Historical and current presence-absence of coho salmon (*Oncorhynchus kisutch*) in the Central California Coast Evolutionarily Significant Unit. NMFS Administrative Report SC-99-02. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Tiburon, California. April, 1999.

Alexander, G.R., and E.A. Hansen. 1986. Sand bed load in a brook trout stream. North American Journal of Fisheries Management 6:9-23.

Alley, D.W. 2009. Appendix A: Fisheries in San Lorenzo Valley Water District Watershed Management Plan. D.W. Alley & Associates, Brookdale, California.

Alley, D.W. 2013. Special Status Species Monitoring Report for the Fall Creek Fish Ladder Improvement Project − Phase I, Santa Cruz County (Streambed Alteration Agreement Notification No. 1600-2013-0204-R3). D.W. Alley & Associates, Brookdale, California.

Alley, D.W. 2015. 2014 Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds, Santa Cruz County, California. Prepared for Santa Cruz County Environmental Health Department, Santa Cruz, California. D.W. Alley & Associates, Brookdale, California.

Alley, D.W. 2018a. Report to the San Lorenzo Valley Water District − Fishery Implications of Water Temperature Data Collected in 2014−2017. Prepared for the San Lorenzo Valley Water District, Boulder Creek, California. D.W. Alley & Associates, Brookdale, California.

Alley, D.W. 2018b. Fall Creek Salmonid Passage Study, Downstream of the Fish Ladder and Water Diversion, Santa Cruz County – Spring 2016. Prepared for the San Lorenzo Valley Water District, Boulder Creek, California. D.W. Alley & Associates, Brookdale, California.

Alley, D.W. 2019. Biological Assessment, Impact Analysis and Mitigation Measures for Fishery Resources at the Huckleberry Island Bridge Abutment Removals Along the San Lorenzo River in Brookdale, CA – March 2019. Prepared for: Biotic Resources Group, Soquel, California. D.W. Alley & Associates, Brookdale, California.

Alley, D.W. 2021. Draft 2020 Summary Report − Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Pajaro Watersheds, Santa Cruz County, California. Prepared for the Santa Cruz County Environmental Health Department, Santa Cruz, California. D.W. Alley & Associates, Brookdale, California.

Baker, P. and F. Reynolds. 1986. Life history, habitat requirements, and status of coho salmon in California. CDFG unpublished report submitted to the California Fish and Game Commission. 31 pages.

Balance Hydrologics, Inc. 2015. Baseline Report of Streamflow, Temperature and Related Observations For the San Lorenzo Valley Water District's Surface Sources of Community Water Supply, Year 1, WY 2014. Prepared for the San Lorenzo Valley Water District. Boulder Creek, California. 224 pages.

Balance Hydrologics, Inc. 2018a. Baseline Report of Streamflow, Temperature and Related Observations for the San Lorenzo Valley Water District's Surface Sources of Community Water Supply. Year 2, WY 2015. Prepared for the San Lorenzo Valley Water District. Boulder Creek, California. 265 pages.

Balance Hydrologics, Inc. 2018b. Baseline Report of Streamflow, Temperature and Related Observations for the San Lorenzo Valley Water District's Surface Sources of Community Water Supply. Year 3, WY 2016. Prepared for the San Lorenzo Valley Water District. Boulder Creek, California. 253 pages.

Balance Hydrologics, Inc. 2019. Baseline Report of Streamflow, Temperature and Related Observations for the San Lorenzo Valley Water District's Surface Sources of Community Water Supply. Year 4, WY 2017. Prepared for the San Lorenzo Valley Water District. Boulder Creek, California. 231 pages.

Barnhart, R.A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest), steelhead. United States Fish and Wildlife Service Biological Report 82 (11.60). 21 pages.

Beamish, R.J., editor. 2018. The ocean ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, Maryland.

Becker, G.S. and I.J. Reining. 2008. Steelhead/rainbow trout (*Oncorhynchus mykiss*) resources south of the Golden Gate, California. Cartography by D.A. Asbury. Center for Ecosystem Management and Restoration. Oakland, California.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria, U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Berg, L., and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42:1410-1417.

Bjorkstedt, E.P, B.C. Spence, J.C. Garza, D.G. Hankin, D. Fuller, W.E. Jones, J.J. Smith, and R. Macedo. 2005. An Analysis of Historical Population Structure for Evolutionarily Significant Units of Chinook Salmon, Coho Salmon, and Steelhead in the North-Central California Coast Recovery Domain. NOAA Technical Memorandum NOAA-TM-NMFS_SWFSC-382. 210 pages.

Bjornn, T.C., M.A. Brusven, M.P. Molnau, J.H. Milligan, R.A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effect on insects and fish. University of Idaho, Forest, Wildlife, and Range Experiment Station, Bulletin 17, Moscow, Idaho.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in W.R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, Maryland. 751 pages.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of the South-Central/Southern California Coast: Population Characterization for Recovery Planning. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-394. NOAA's National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, California.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2007. Viability Criteria for Steelhead of the South-Central and Southern California Coast. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-407. NOAA's National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, California.

Bond, M.H., S.A. Hayes, C.V. Hanson, and R.B. MacFarlane. 2008. Marine survival of steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fisheries and Aquatic Sciences 65: 2242–2252.

Brewer, P.G., and J. Barry. 2008. Rising Acidity in the Ocean: The Other CO_2 Problem. Scientific American. October 7, 2008.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

Bryant, G.J. 1994. Status review of coho salmon populations in Scott and Waddell Creeks, Santa Cruz County, California. National Marine Fisheries Services Southwest Region, Santa Rosa, California.

Busby, P.J., T.C. Wainwright, G.J. Bryant., L. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. United States Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NOAA Fisheries-NWFSC-27. 261 pages.

Cal Fire and CDC (California Department of Forestry and Fire Protection and California Department of Conservation). 2020. Watershed Emergency Response Team Evaluation, CZU Lightening Complex. CA-CZU-005205. California Department of Forestry and Fire Protection and California Department of Conservation California Geological Survey. October 2020.

CDFG (California Department of Fish and Game). 2000. Fish Screen Criteria. June 19.

CDFG (California Department of Fish and Game). 2012. Critical Riffle Analysis for Fish Passage in California. California Department of Fish and Game Instream Flow Program Standard Operating Procedure DFG-IFP-001, 24 pages.

Casagrande, J. 2020. Uvas Creek Juvenile Steelhead Distribution and Abundance and Adult Observations, 2019. Prepared for the California Department of Fish and Wildlife and the National Marine Fisheries Service. 25 January 2020. 52 pages.

Cayan, D., M. Tyree, and S. Iacobellis. 2012. Climate Change Scenarios for the San Francisco Region. Prepared for California Energy Commission. Publication number: CEC-500-2012-042. Scripps Institution of Oceanography, University of California, San Diego.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117(1):1-21.

Coble, D.W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Transactions of American Fisheries Society 90:469-474.

Cordone, A.J., and D.W. Kelly. 1961. The influences of inorganic sediment on the aquatic life of streams. California Fish and Game 47:189-228.

County of Santa Cruz. 2019. Juvenile Steelhead and Stream Habitat (JSSH) web, database available at https://sccwrp.shinyapps.io/jssh_web/_w_39c44ce4/index.Rmd0

Cox, P., and D. Stephenson. 2007. A changing climate for prediction. Science 113:207-208.

Crouse, M.R., C.A. Callahan, K.W. Malueg, and S.E. Dominguez. 1981. Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Transactions of the American Fisheries Society 110: 281-286.

Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5:330-339.

Doney, S.C., M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. Sydeman, J., and L. D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science 4:11-37.

Dolman, B., J. Green, M.A. King, M. Obedzinski, S. Nossaman, and K. Robbins. 2019. Upper Green Valley Creek Streamflow Improvement Plan. The Russian River Coho Water Resources Partnership. December 2019. 109 pages.

Eisler, R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 1, Metals. Lewis Press. Boca Raton, Florida.

Everest, F.H., R.L. Beschta, J.C. Schrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1987. Fine sediment and salmonid production: A paradox. *In*: Salo, E.O., T.W. Cundy, editors. Streamside Management. Forestry and Fishery Interactions. University of Washington, Institute of Forest Resources. Contribution No. 57. P. 98-142.

Exponent. 2019. Water Availability Assessment for San Lorenzo River Watershed Conjunctive Use Plan. Prepared for San Lorenzo Valley Water District, Boulder Creek, California.

Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, F.J. Millero. 2004. Impact of anthropogenic CO_2 on the $CaCO_3$ system in the oceans. Science 305:362-366.

Fukushima L., and E.W. Lesh. 1998. Adult and juvenile anadromous salmonid migration timing in California streams. California Department of Fish and Game 84(3):133-145.

Furniss, M.J., T.D. Roelofs, and C.S. Lee. 1991. Road construction and maintenance. Pages 297-323 in W. R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. American Fisheries Society Special Publication 19. 622 pages.

Goin, M.D. 2015. Escapement Estimates for Central California Coast Coho Salmon (*Oncorhynchus kisutch*) and Steelhead (*Oncorhynchus mykiss*) in Coastal San Mateo and Santa Cruz Counties for 2013-2014. 65 pages.

Goin, M.D. 2016. 2014-2015 Escapement Estimates for Central California Coast Coho Salmon (*Oncorhynchus kisutch*) and Steelhead (*Oncorhynchus mykiss*) in Coastal San Mateo and Santa Cruz County streams. 54 pages.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. United States Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66. 598 pages.

Gregory, R.S., and T.G. Northcote. 1993. Surface, planktonic, and benthic foraging by juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in turbid laboratory conditions. Canadian Journal of Fisheries and Aquatic Sciences 50:233-240.

Grunblatt, J., B.E. Meyers, and M.S. Wipfli. 2019. Invertebrate prey contributions to juvenile Coho Salmon diet from riparian habitats along three Alaska streams: Implications for environmental change. Journal of Freshwater Ecology 34(1):617-631.

Hagar, J. 2005. Mount Hermon Summer Dam Improvement Project Fish Removal Activities. Technical Memorandum. Prepared for: Mount Hermon Association, Inc., Mount Hermon, California. Hagar Environmental Science, Richmond, California. November 8, 2005.

Harvey, B.C. 1986. Effects of suction gold dredging on fish and invertebrates in two California streams. North American Journal of Fisheries Management 6:401-409.

Hassler, T.J. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) coho salmon. U.S. Fish and Wildlife Service, Biological Report. 82(11.70). U.S. Army Corps of Engineers.

Hayes, D.B., C.P. Ferreri, and W.W. Taylor. 1996. Active fish capture methods. Pages 193-220 in B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, Maryland. 732 pages.

Hayes, S.A., M.H. Bond, C.V. Hanson, E.V. Freund, J.J. Smith, E.C. Anderson, A.J. Ammann, and B.R. MacFarlane. 2008. Steelhead growth in a small Central California watershed: Upstream and estuarine rearing patterns. Transactions of the American Fisheries Society 137: 114-128.

Hayhoe, K., D. Cayan, C.B. Field, P. C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America, 101(34):12422-12427.

Hokanson, K.E.F., C.F. Kleiner, and T.W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates of juvenile rainbow trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34:639-648.

Holtby, L.B., B.C. Anderson, and R.K. Kadowaki. 1990. Importance of smolt size and early ocean growth to interannual variability in marine survival of coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 47(11):2181-2194.

Hubert, W.A. 1996. Passive capture techniques. Pages 157-192 *in* B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, Maryland.

Jankovitz, J. 2013. 2012-2013 Escapement Estimates for Central California Coast Coho Salmon (*Oncorhynchus kisutch*) and Steelhead (*Oncorhynchus mykiss*) South of the Golden Gate. 42 pages.

Kadir, T., L. Mazur, C. Milanes, K. Randles, and (editors). 2013. Indicators of Climate Change in California. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment.

Keeley, E.R. 2003. An experimental analysis of self-thinning in juvenile steelhead trout. Oikos 102:543-550.

Lindley, S.T., R.S. Schick, E. Mora, P.B. Adams, J.J. Anderson, S. Greene, C. Hanson, B.P. May, D.R. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2007.

Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Lusardi, R.A., B.G. Hammock, C.A. Jeffres, R.A. Dahlgren, and J.D. Kiernan. 2020. Oversummer growth and survival of juvenile coho salmon (*Oncorhynchus kisutch*) across a natural gradient of stream water temperature and prey availability: an in situ enclosure experiment. Canadian Journal of Fisheries and Aquatic Sciences 77(2):413-424.

McClure, M. M., M. Alexander, D. Borggaard, D. Boughton, L. Crozier, R. Griffis, J. C. Jorgensen, S.T. Lindley, J. Nye, M.J. Rowland, E.E. Seney, A. Snover, C. Toole, and K. Van Houtan. 2013. Incorporating climate science in applications of the U.S. endangered species act for aquatic species. Conservation Biology 27:1222-1233.

McMahon, T. E. 1983. Habitat suitability index models: coho salmon. United States Fish and Wildlife Service, FWS/OBS-82/10.49.

Martin, J.A. 1995. Food habits of some estuarine fishes in a small, seasonal central California lagoon. Masters of Science Thesis. San José State University. 57 pages.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. National Marine Fisheries Services, Northwest Fisheries Science Center and Southwest Fisheries Science Center.

Merritt, R.W., and K.W. Cummins, editors. 1996. An introduction to the aquatic insects of North America, 3rd ed. Kendall/Hunt Pub. Co, Dubuque, Iowa.

Moser, S., J. Ekstrom, and G. Franco. 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California. A Summary Report on the Third Assessment from the California Climate change Center.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley and Los Angeles, California.

Myrick, C., and J.J. Cech, Jr. 2005. Effects of Temperature on the Growth, Food Consumption, and Thermal Tolerance of Age-0 Nimbus-Strain Steelhead. North American Journal of Aquaculture 67:324-330.

NMFS (National Marine Fisheries Service). 1997a. Fish screening criteria for anadromous salmonids. National Marine Fisheries Service, Southwest Region. 12 pages.

NMFS (National Marine Fisheries Service). 1997b. Status update for West Coast steelhead from Washington, Idaho, Oregon, and California. Memorandum date 7 July 1997 from the Biological Review Team to the National Marine Fisheries Service Northwest Regional Office.

NMFS (National Marine Fisheries Service). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. National Marine Fisheries Service, Protected Resources Division, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2001. Guidelines for salmonid passage at stream crossings. National Marine Fisheries Service Southwest Region. 14 pages.

NMFS (National Marine Fisheries Service). 2011. Anadromous salmonid passage facility design. NMFS, Northwest Region, Portland, Oregon. 140 pages.

NMFS (National Marine Fisheries Service). 2012. Final Recovery Plan for Central California Coast coho salmon Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2016a. 5-year Review: Summary & Evaluation of Central California Coast Coho Salmon. National Marine Fisheries Service, West Coast Region. California Coastal Office, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2016b. Final coastal multispecies recovery plan: California Coastal Chinook salmon, Northern California steelhead, Central California Coast steelhead. National Marine Fisheries Service, West Coast Region. California Coastal Office, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2019. Approval of NMFS Design Variance, Maximum Hydraulic Drop Criterion. Letter from David K. White, NMFS Fish Passage Engineer, April 19, 2019.

Nielsen, J.L. 1992. Microhabitat-specific foraging behavior, diet, and growth of juvenile coho salmon. Transactions of the American Fisheries Society 121:617-634.

Ohms, H.A., and D.A. Boughton. 2019. Carmel River steelhead fishery report – 2019. Prepared for California-American Water Company. Prepared by NOAA National Marine Fisheries Service Southwest Fisheries Science Center and University of California Santa Cruz Institute of Marine Science. Santa Cruz, California. 44 pages.

Osgood, K.E. 2008. Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-F/SPO-89.

PFMC (Pacific Fishery Management Council). 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.

Phillips, R.W., and H.J. Campbell. 1961. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Pages 60-73 in 14th annual report to Pacific Marine Fisheries Commission. Portland, Oregon.

Podlech, M. 2018. Fall Creek reconnaissance-level assessment of channel characteristics. Prepared for San Lorenzo Valley Water District. Boulder Creek, California. 8 pages.

Podlech, M. 2020. Fall Creek Fish Ladder Improvement Project Biological Assessment and Essential Fish Habitat Assessment. Prepared for the San Lorenzo Valley Water District, Boulder Creek, California. April, 23, 2020. 73 pages.

RCDSCC (Resource Conservation District of Santa Cruz County). 2020. RCDSCC Fall Creek Fish Ladder Project Mitigation, Monitoring and Reporting Plan (MMRP). Prepared for the Central Coast Regional Water Quality Control Board. Submitted July 14, 2020. 13 pages.

Reeves, G.H., J.D. Hall, T.D. Roelofs, T.L. Hickman, and C.O. Baker. 1991. Rehabilitating and modifying stream habitats. Pages 519-557 *in* W.R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, Maryland.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat Requirements of Anadromous Salmonids. *In*: Meehan, W.R., Technical Editor. Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. United States Department of Agriculture, Forest Service GTR PNW-96. 54 pages.

Robinson, M.A. 1993. The distribution and abundance of benthic and epibenthic macroinvertebrates in a small, seasonal Central California Lagoon. Master's Thesis, San José State University. 77 pages.

Ruggiero, P., C.A. Brown, P.D. Komar, J.C. Allan, D.A. Reusser, H. Lee, S.S. Rumrill, P. Corcoran, H. Baron, H. Moritz, and J. Saarinen. 2010. Impacts of climate change on Oregon's coasts and estuaries. Pages 241-256 in K. D. Dellow, and P. W. Mote, editors. Oregon Climate Assessment Report, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon.

Rundio, D.E. and S.T. Lindley. 2008. Seasonal Patterns of Terrestrial and Aquatic Prey Abundance and Use by *Oncorhynchus mykiss* in a California Coastal Basin with a Mediterranean Climate. Transactions of the American Fisheries Society. 137(2):467-480.

Sandercock, F.K. 1991. Life history of coho salmon. Pages 397-445 *in* C. Groot, and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.

Santer, B.D., C. Mears, C. Doutriaux, P. Caldwell, P.J. Gleckler, T.M.L. Wigley, S. Solomon, N.P. Gillett, D. Ivanova, T.R. Karl, J.R. Lanzante, G.A. Meehl, P.A. Stott, K.E. Talyor, P.W. Thorne, M.F. Wehner, and F.J. Wentz. 2011. Separating signal and noise in atmospheric temperature changes: The importance of timescale. Journal of Geophysical Research 116: D22105.

Satterthwaite, W.H., M.P. Beakes, E.M. Collins, D.R. Swank, J.E. Merz, R.G. Titus, S.M. Sogard, and M. Mangel. 2009. Steelhead life history on California's Central Coast: Insights from a state-dependent model. Transactions of the American Fisheries Society 138: 532–548.

Scavia, D., J.C. Field, B.F. Boesch, R.W. Buddemeier, V. Burkett, D.R. Cayan, M. Fogarty, M. A. Harwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallenger, and J.G. Titus. 2002. Climate change impacts on U.S. coastal and marine ecosystems. Estuaries 25(2):149-164.

Schneider, S.H. 2007. The unique risks to California from human-induced climate change. May 22, 2007. Environmental Protection Agency.

Schmetterling, D.A., C.G. Clancy, and T.M. Brandt. 2001. Effects of riprap bank reinforcement on stream salmonids in the Western United States. Fisheries 26(7):6–13.

Servizi, J.A., and D.W. Martens. 1992. Sublethal responses of coho salmon (*Oncorhynchus kisutch*) to suspended sediments. Canadian Journal of Fisheries and Aquatic Sciences 49:1389-1395.

Shapovalov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Fish Bulletin 98.

Shirvell, C. 1990. Role of instream rootwads as juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) cover habitat under varying streamflows. Canadian Journal of Fisheries and Aquatic Sciences 47(5):852-861.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. *In* Estuarine comparisons. Edited by V.S. Kennedy. Academic Press, New York. pp. 343–364.

Smith, D.M., S. Cusack, A.W. Colman, C.K. Folland, G.R. Harris, and J.M. Murphy. 2007. Improved surface temperature prediction for the coming decade from a global climate model. Science 317:796-799.

Smith, J.J. 1982. Fishes of the Pajaro River system. Studies on the distribution and ecology of stream fishes of the Sacramento-San Joaquin drainage system, pp. 83–169. *In*: P.B. Moyle (ed.) Smith, J.J. 115, Berkeley, California.

Smith, J.J. 1990. The effects of sandbar formation and inflows on aquatic habitat and fish utilization in Pescadero, San Gregorio, Waddell, and Pomponio creek estuary/lagoon systems, 1985-1989. Prepared for California Department of Parks and Recreation. Report Interagency Agreement 84-04-324, San José State University.

Smith, J.J. 2020. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell, and Scott Creeks in 2020. Department of Biological Sciences, San Jose State University, California. 130 pages.

Sogard, S.M. T.H. Williams and H. Fish. 2009. Seasonal Patterns of Abundance, Growth, and Site Fidelity of Juvenile Steelhead in a Small Coastal California Stream. Transactions of the American Fisheries Society 138:549–563.

Spence, B.C., E. P. Bjorkstedt, J.C. Garza, J.J. Smith, D.G. Hankin, D. Fuller, W.E. Jones, R. Macedo, T.H. Williams, and E. Mora. 2008. A Framework for Assessing the Viability of Threatened and Endangered Salmon and Steelhead in the North-Central California Coast Recovery Domain U.S. Department of Commerce, National Marine Fisheries Service, Southwest Fisheries Service Center, NOAA-TM-NMFS-SWFSC-423, Santa Cruz, California.

Spence, B.C., E.P. Bjorkstedt, S. Paddock, and L. Nanus. 2012. Updates to biological viability criteria for threatened steelhead populations in the north-central California coast recovery domain. U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division. March 2012.

Spence, B., G. Lomnicky, R. Hughes, and R. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. Technical Environmental Research Services Corp., Corvallis, Oregon. 356 pages.

Spencer, J., 1928. Fish Screens in California Irrigation Ditches, California Fish and Game 14(3), 208-210 pp.

Sweka, J.A., and K.J. Hartman. 2008. Contribution of terrestrial invertebrates to yearly brook trout prey consumption and growth. Transactions of the American Fisheries Society 137(1):224–235.

Thomas, V.G. 1985. Experimentally determined impacts of a small, suction gold dredge on a Montana stream. North American Journal of Fisheries Management 5:480-488.

Thompson, K.E. 1972. Determining streamflows for fish life. pp. 31-50 *in* Proceedings of the Instream Flow Requirement Workshop. Pacific N.W. River Basins Commission. Portland, Oregon.

Turley, C. 2008. Impacts of changing ocean chemistry in a high-CO_2 world. Mineralogical Magazine 72(1):359-362.

Velagic, E. 1995. Turbidity study: a literature review. Prepared for Delta planning branch, California Department of Water Resources by Centers for Water and Wildland Resources, University of California, Davis.

Wagner, C.H. 1983. Study of Upstream and Downstream Migrant Steelhead Passage Facilities for the Los Padres Project and New San Clemente Project, Report prepared for the Monterey Peninsula Water Management District.

Waters, T.F. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Fisheries Society Monograph 7.

Waterways (Waterways Consulting, Inc.). 2020. Fall Creek Fish Ladder Improvement Project - 90% Fish Passage Design Hydraulic Report. Prepared for the San Lorenzo Valley Water District. Boulder Creek, California. 24 pages.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. United States Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-24. 258 pages.

Welsh, H., G.R. Hodgson, B.C. Harvey, and M.E. Roche. 2001. Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California. North American Journal of Fisheries Management 21:464-470.

Westerling, A.L., B.P. Bryant, H. K. Preisler, T.P. Holmes, H.G. Hidalgo, T. Das, and S.R. Shrestha. 2011. Climate change and growth scenarios for California wildfire. Climatic Change 109:(Suppl 1):S445–S463.

Williams, T.H., S.T. Lindley, B.C. Spence, and D.A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. 20 May 2011, update to 5 January 2011 Report to Southwest Region National Marine Fisheries Service from Southwest Fisheries Science Center, Fisheries Ecology Division.

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S. T. Lindley. 2016. Viability Assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest, 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California.

Wurtsbaugh, W.A., and G.E. Davis. 1977. Effects of temperature and ration level on the growth and food conversion efficiency of *Salmo gairdneri*, Richardson. Journal of Fish Biology 11:87-98.