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CITY OF SANTA CRUZ ANADROMOUS SALMONID HABITAT CONSERVATION PLAN

for the

ISSUANCE OF AN INCIDENTAL TAKE PERMIT UNDER SECTION 10(a)(1)(B) OF THE ENDANGERED SPECIES ACT

Prepared for:

City of Santa Cruz
809 Center Street
Santa Cruz, CA 95060

Prepared by:

City of Santa Cruz Water Department, Ebbin Moser + Skaggs LLP, Hagar Environmental Science, Gary Fiske and Associates, Balance Hydrologics, Inc., Alnus Ecological

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Acknowledgements

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Executive Summary

Introduction

The City of Santa Cruz (City) has applied for an incidental take permit (ITP) from the National Marine Fisheries Service (NMFS) pursuant to section 10(a)(1)(B) of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. §1531 *et seq.*) to incidentally take the federally threatened Central California Coast steelhead (*Oncorhynchus mykiss*) (steelhead) and federally endangered Central California Coast coho (*Oncorhynchus kisutch*) (coho). The incidental take is anticipated to occur as a result of City Covered Activities within the area covered by the City of Santa Cruz Anadromous Salmonid Habitat Conservation Plan (HCP). The HCP provides for permit coverage for a wide range of City activities. These Covered Activities include operation, maintenance, and rehabilitation of the City's water supply and water system facilities; operation and maintenance of the City's municipal facilities; and management of City lands. The City requests that the section 10(a)(1)(B) permit be issued for a period of 30 years.

Plan Area

The area covered by this HCP (Plan Area) is located in Santa Cruz County on the central coast of California, approximately 70 miles south of San Francisco. The Plan Area is shown on Figure 1-1. The Plan Area is contained on the Davenport, Santa Cruz, and Felton U.S. Geological Survey 7.5-minute quadrangles. The total watershed and water service/urban areas containing the general Plan Area are approximately 176 square miles and include three geographically distinct areas: the North Coast watersheds, the San Lorenzo River watershed, and the Santa Cruz urban center, as well as the water service areas outside of the City limits. The regional topography ranges from sea level to greater than 1,200 feet above sea level.

The 18 square mile North Coast watersheds (Liddell, Laguna, and Majors), which serve as drinking water source watersheds for the City, comprise a series of small coastal watersheds that drain the west and south-facing slopes of the Santa Cruz Mountains directly to the Pacific Ocean. In most cases, these watersheds include forested slopes in the upper reaches and canyon portions of the watershed, coastal foothill terraces, agricultural lands on the coastal plain, and streams that typically drain into seasonal lagoons.

The San Lorenzo River watershed is a 138 square mile area located along the Central Coast of California and drains from the Castle Rock area of Summit to the north, Ben Lomond Mountain on the west, and the Branciforte area on the eastside down to the Pacific Ocean at the north end of Monterey Bay by the Santa Cruz Beach Boardwalk. The watershed is significantly more developed than the North Coast watersheds, though is also characterized by significant open space acreage as well.

Finally, the Santa Cruz urban center and water service areas are characterized by suburban and urban areas on the lower marine terraces ranging from approximately 41st Avenue on the east to Western Drive on the west and from the Pacific Ocean on the south to unincorporated areas of Santa Cruz County just north of the City of Santa Cruz limits. It should be noted that the City of Santa Cruz water service area overlaps with significant areas of both the North Coast watersheds and the San Lorenzo River watershed.

Covered Species

Steelhead (Oncorhynchus mykiss)

Steelhead inhabiting the drainages within the Plan Area are part of the Central California Coast Distinct Population Segment (DPS) listed as threatened under the federal ESA (NMFS 2006). The Central California Coast DPS consists entirely of winter-run steelhead and extends from the Russian River south to Aptos Creek in the southern end of Santa Cruz County. The Plan Area is located in the southern range of the Central California Coast DPS (Busby et al. 1996). Streams in the HCP plan area are included in the critical habitat designation for CCC Steelhead (NMFS 2005). Recovery of the Central California Coast Steelhead DPS is addressed in the *Coastal Multispecies Final Recovery Plan: California Coastal Chinook Salmon ESU, Northern California Steelhead DPS and Central California Coast Steelhead DPS*, released in October 2016 (NMFS 2016).

Coho (Oncorhynchus kisutch)

Coho in the Plan Area are part of the Central California Coast ESU, which is listed as endangered under the federal ESA. The Central California Coast Evolutionarily Significant Unit (ESU) extends from Punta Gorda in Humboldt County south to, and including Aptos Creek (NMFS 2005b). Critical habitat has been designated for the Central California Coast ESU and includes the accessible portions of the streams in the Plan Area. Recovery of the Central California Coast coho is addressed in the *Final Recovery Plan for Central California Coast Coho Salmon Evolutionarily Significant Unit* (NMFS 2012).

Covered Activities

The City's Water Department has several sources of surface water in its system that serve nearly 100,000 people with potable water in the City and surrounding areas of Santa Cruz County. The City diverts water from its North Coast Diversions (including Liddell Spring, Reggiardo Creek, Laguna Creek and Majors Creek), the San Lorenzo River (including the Felton and Tait Street[1] diversions), Newell Creek Dam and Reservoir (commonly referred to as Loch Lomond Reservoir) and the Live Oak Wells (see Figure 3-1 - City of Santa Cruz Water System map). The HCP will provide coverage for water diversion and for operation, rehabilitation, replacement, repair and maintenance of conveyance facilities and other existing infrastructure such as water measurement devices, scientific measuring devices, and water quality monitoring stations. The Live Oak Wells draw from deep groundwater with no clear, direct connection to surface water dynamics and are not addressed in this HCP (Montgomery and Associates 2020).

In addition to the Covered Activities outlined above, the Plan provides coverage for the following Covered Activities: municipal facility operations and maintenance (including flood control channel operation and maintenance); land management; monitoring, and habitat restoration. Information on the Covered Activities is found in Chapter 3 of the HCP.

Conservation Strategy

The City's development of the conservation strategy included a thorough review of available data and literature on the species and extensive field data collection regarding the status and features of populations and habitat conditions within each stream. This analysis resulted in the identification of limiting factors (Chapter 2), and an understanding of the potential effects of Covered Activities on these species and their habitats. As described in Chapter 1, the City coordinated closely with NMFS and the California Department of Fish and Wildlife (CDFW) to address research methodologies and results and develop the conservation strategy. The primary focus of the City's conservation strategy is to avoid or minimize potential effects of Covered Activities to the maximum extent practicable by reducing surface water diversions and second to compensate for remaining effects by contributing to regional, non-flow conservation actions for steelhead and coho. The following describes the City's approach to the conservation strategy.

Instream Flows

A major element of the Conservation Strategy involves identification of minimum bypass flows at City diversions to minimize the effect of diversions on habitat conditions for steelhead and coho. Flow reductions, particularly during the summer low-flow season, represent one of the City's major effects on steelhead and coho in the Plan Area. There are currently no instream or bypass flow requirements for the Tait Street or North Coast diversions, although diversion amounts are limited by water rights and facilities limitations. The conservation strategy specifies minimum flows for each of the streams that the City diverts water from that would be maintained

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[1] The Tait Street Diversion is located adjacent to Crossing and River Streets in Santa Cruz and is sometimes also referred to as the San Lorenzo River Diversion.

through flow bypasses at the City's diversions. Instream flow alternatives were modeled using the City's water supply operations model (*Confluence*® Model) to determine the effects on the City's ability to serve customer demands as well as the resulting instream habitat conditions. The minimum instream flows (Conservation Flows) and the strategy for implementing them are described in detail in Section 4.4.

Non-flow Conservation Actions

Where the avoidance and minimization measures are insufficient to entirely avoid potential effects to the Covered Species, the City will provide compensatory mitigation to fully offset those remaining effects. Specifically, the City will fund non-flow conservation actions aimed at habitat enhancement and restoration that provide opportunities to support species recovery (Section 4.5) (Appendix 1: *Summary of Approach to Non-Flow Mitigation of Biological Effects of the City Diversions*). These conservation actions will include improvement of instream habitat, riparian conservation, and prioritization of support for coho hatchery development and operations as well as other related recovery actions. Details of this program element can be found in Appendix 1: *Summary of Approach to Non-Flow Mitigation of Biological Effects of the City Diversions*.

Plan Implementation

The HCP identifies the issues that are related to implementation and the approaches that will be used to address those issues over the term of the HCP. Chapter 6 describes requirements for short-term and long-range planning, budgets, monitoring, and compliance reporting. The chapter further describes the regulatory assurances under the ESA that are expected to be provided to the City. It also describes the commitment of the City to respond to foreseeable changes in circumstances that may adversely affect Covered Species and habitats and identifies a process by which changes that are not foreseeable can be addressed. Finally, the chapter identifies the circumstances under which the permit may be suspended or revoked by NMFS.

Funding

The ESA requires that a conservation plan approved pursuant to the federal law must assure availability of adequate funding to implement the plan's conservation actions. ESA Section 10 (16 U.S.C. Sec. 1539) states that, prior to approving a habitat conservation plan and issuing an incidental take permit, the Secretary of Commerce must find, among other conditions, that "the applicant will ensure that adequate funding for the plan will be provided." The City has identified in the HCP the funding that will be available to implement the actions identified and has committed to ensure that adequate funding for the HCP will be provided. The information outlining the costs of the HCP and the associated funding mechanisms to meet the requirements of the ESA are found in Chapter 7.

Alternatives

Section 10 of the ESA and its regulations require that an HCP describe alternatives considered that would avoid incidental taking and the reasons why they were not adopted. Chapter 8 describes the No Action Alternative, under which a section 10(a)(1)(B) permit would not be issued. Under the No Action Alternative, City activities with the potential to cause incidental take of listed species would require measures to avoid incidental take or individual incidental take authorizations on a project-by-project basis. Chapter 8 also describes a Reduced Covered Activities Alternative under which the City would limit the HCP to bypass flows and the numerous activities associated with operations and maintenance of the water supply system would not be covered by the permit.

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List of Acronyms and Abbreviations

ASR	Aquifer Storage and Recovery
BMP	best management practice
C	Celsius
CDFW	California Department of Fish and Wildlife
CDL	Coast Dairies and Land Co.
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CIP	Capital Improvement Program
CLEAP	Comparative Lagoon Ecological Assessment Project
cm	centimeter
CMP	California Coastal Salmonid Population Monitoring Program
CPUE	catch per unit effort
CRA	critical riffle analysis
dbh	diameter at breast height
DIN	dissolved inorganic nitrogen
DO	dissolved oxygen
DPS	Distinct Population Segment
DSOD	Division of Safety of Dams
ESU	Evolutionarily Significant Unit
ESA	Endangered Species Act
FCC	flood control channel
FAO	Food and Agriculture Organization
FEMA	Federal Emergency Management Agency
FIB	Fecal Indicator Bacteria
FL	fork length
FTE	full time equivalent
GIS	geographic information system
gpm	gallons per minute
GRTS	general random tessellation stratified
HC	hydrologic conditions
HCP	Habitat Conservation Plan
in	inch
IPM	Integrated Pest Management
ITP	Incidental Take Permit
IWRP	Integrated Watershed Restoration Program
l	liter
LCRS	Leachate Collection and Removal System
LLRA	Loch Lomond Recreation Area

LWD	large woody debris
m	meter
MBSTP	Monterey Bay Salmon and Trout Project
mg	milligrams
MGD	million gallons per day
mm	millimeter
MOA	Memorandum of Agreement
msl	mean sea level
MS4s	Small Municipal Separate Storm Sewer Systems
MTC	Monitoring Technical Committee
MWAT	Seven-Day Moving Average Temperature
NCS	North Coast System
NEPA	National Environmental Policy Act
NFCF	Non-Flow Conservation Fund
NGVD 29	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NO_3^-	dissolved nitrate
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
NWS	National Weather Service
PHABSIM	Physical Habitat Simulation
POD	points of diversion
POU	place of use
ppm	parts per million
PIT	passive integrated transponder
ppt	parts per thousand
PWA	Philip Williams and Associates
ROW	right-of-way
RWQCB	Regional Water Quality Control Board
SCWD	Santa Cruz Water Department
SKOF	Silver-King Ocean Farms
SOP	standard operating procedure
SRP	Soluble Reactive Phosphorous
SLVWD	San Lorenzo Valley Water District
SVWD	Scotts Valley Water District
SWMP	Stormwater Management Plan
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TAMF	Take Avoidance and Minimization Fund

TMDL	Total Maximum Daily Load
UCSC	University of California, Santa Cruz
US EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WMO	World Meteorological Organization
WSE	water surface elevation
WSAC	Water Supply Advisory Committee
WUA	weighted useable area
YOY	young-of-year

1.0 INTRODUCTION

The City of Santa Cruz (City) has applied for an incidental take permit (ITP) from the National Marine Fisheries Service (NMFS) pursuant to section 10(a)(1)(B) of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 *et seq.*) to incidentally take the federally threatened Central California Coast steelhead (*Oncorhynchus mykiss*) (steelhead) and federally endangered Central California Coast coho salmon (*Oncorhynchus kisutch*) (coho). The incidental take is anticipated to occur as a result of City Covered Activities within the Plan Area for the City of Santa Cruz Anadromous Salmonid Habitat Conservation Plan (HCP). These Covered Activities include operation, maintenance, and repair of the City's water supply and water system facilities; operation and maintenance of the City's municipal facilities; and management of City lands. The City requests that the section 10(a)(1)(B) permit be issued for a period of 30 years.

1.1 Purpose

The City provides a wide range of essential public services for its citizens and visitors, such as the construction, operation and maintenance of water supply facilities, the construction and maintenance of roads, waste management activities, stormwater management, and the operation and maintenance of recreation and open space areas. The City has determined that activities it undertakes to provide these services may adversely affect the life history and habitat of steelhead and coho, the Covered Species under the HCP.

The ESA and the implementing regulations prohibit the unauthorized "take" of an animal species that is listed as threatened or endangered. "Take" includes a range of activities that could result in death or injury to a species, including harm that results from substantial adverse habitat modification. Under section 10 of the ESA, NMFS can authorize the taking of species that is incidental to an otherwise lawful activity, if the landowner first prepares and agrees to implement a habitat conservation plan that meets permit issuance criteria. Among other issuance criteria, a habitat conservation plan must minimize and mitigate to the maximum extent practicable the potential impacts of such incidental take.

To ensure the City's continued ability to provide these essential public services, the City is seeking to obtain a permit from NMFS under section 10(a)(1)(B) of the ESA for the incidental take of steelhead and coho. This HCP provides the basis for the issuance of a Permit under the ESA. This HCP further provides the basis for issuance of an incidental take permit for coho under Section 2081(b) of the California Endangered Species Act.

1.2 Plan Area

The area covered by this HCP (Plan Area) is located in Santa Cruz County on the central coast of California, approximately 70 miles south of San Francisco. The Plan Area is shown on Figure 1-1. The Plan Area is contained on the Davenport, Santa Cruz, and Felton U.S. Geological Survey 7.5-minute quadrangles. The total watershed and water service/urban areas within the Plan Area are approximately 176 square miles and include four geographically distinct areas: the North Coast Unit, the San Lorenzo River Unit, the City Urban Center Unit, and the water service areas outside of the City limits. The regional topography ranges from sea level to greater than 1,200 feet above sea level. See Figure 1-1: HCP Plan Area.

The North Coast Unit is located north of the City along Highway 1 and includes Majors Creek, Laguna Creek, Reggiardo Creek, Liddell Creek, and Lombardi Gulch. The 18-square mile North Coast watersheds serve as drinking water source watersheds for the City and comprise a series of small coastal watersheds that drain the west and south-facing slopes of the Santa Cruz Mountains directly to the Pacific Ocean. These watersheds include forested slopes in the upper reaches and canyon portions of the watershed, coastal foothill terraces, agricultural lands on the coastal plain, and streams that drain to the Pacific Ocean. See Figure 1-2, Figure 1-3, and Figure 1-4 for Liddell, Laguna and Majors Watershed maps respectively.

The 138-square-mile San Lorenzo River watershed drains west and east-facing slopes in the Santa Cruz Mountains that do not receive as much rain as their west-facing counterparts. The San Lorenzo River has a much longer run to the ocean than other Plan Area streams, and is fed by many tributaries including Branciforte, Zayante, Bean, Newell, Bear, Boulder and Fall Creeks. While many of the tributaries exhibit the physical characteristics of coastal streams (e.g., steep gradients, forested slopes), the San Lorenzo River runs through a comparably deep, wide canyon. Finally, the San Lorenzo River is densely developed throughout the floodplain and watershed.

The City’s urban center encompasses approximately 12 square miles centered around the mouth of the San Lorenzo River. The Water Department provides service to the City as well as an area outside of the City limits that is approximately 8 square miles. The City is the largest city in Santa Cruz County, and is home to more than 65,021 residents. Major industries include tourism, manufacturing, food processing, and technology. The University of California, Santa Cruz (UCSC), a world-class university of approximately 19,457 students, is also located within the City. Streams within the City Urban Center Unit are the lower San Lorenzo River and tributaries, and the smaller urban drainages and aquatic resources potentially influenced by Covered Activities, including Neary Lagoon, Laurel Creek, Moore Creek, and Arana Creek. The streams listed under the City Urban Center Unit are located either partially or wholly within the

City limits and are influenced by urban land management activities such as vegetation management, flood control and stormwater management activities, rather than or in addition to surface water diversions. Therefore, the lower San Lorenzo River (from the City limits to the river mouth), Branciforte Creek, Carbonera Creek, and Pogonip Creek, although part of the San Lorenzo River watershed, are discussed under the City Urban Center Unit in this HCP.

The additional area covered by the water service area is located on the North Coast of unincorporated Santa Cruz County to the west of the City of Santa Cruz along the Highway 1 corridor, to the north of the City of Santa Cruz in the suburban areas of the lower San Lorenzo River watershed in the unincorporated areas of Santa Cruz County and to the east of the City of Santa Cruz in the urban unincorporated area of Santa Cruz County in Live Oak.

The City either has regulatory jurisdiction over areas in the Plan Area or has a property interest on lands where Covered Activities occur. As such, the City has sufficient control over the lands subject to Covered Activities to implement the provisions of this HCP.

Figure 1-1: HCP Plan Area

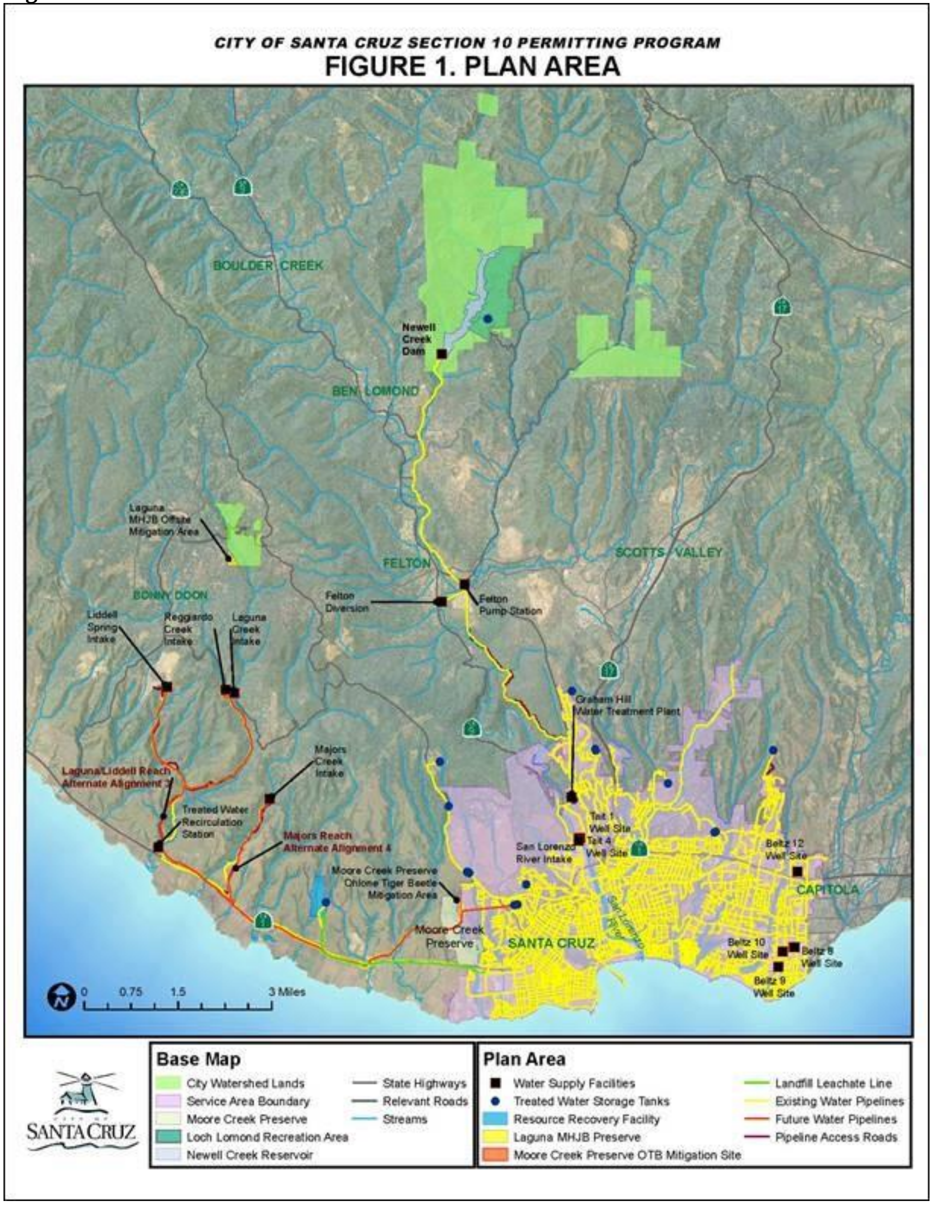


Figure 1-2: Liddell Watershed Map

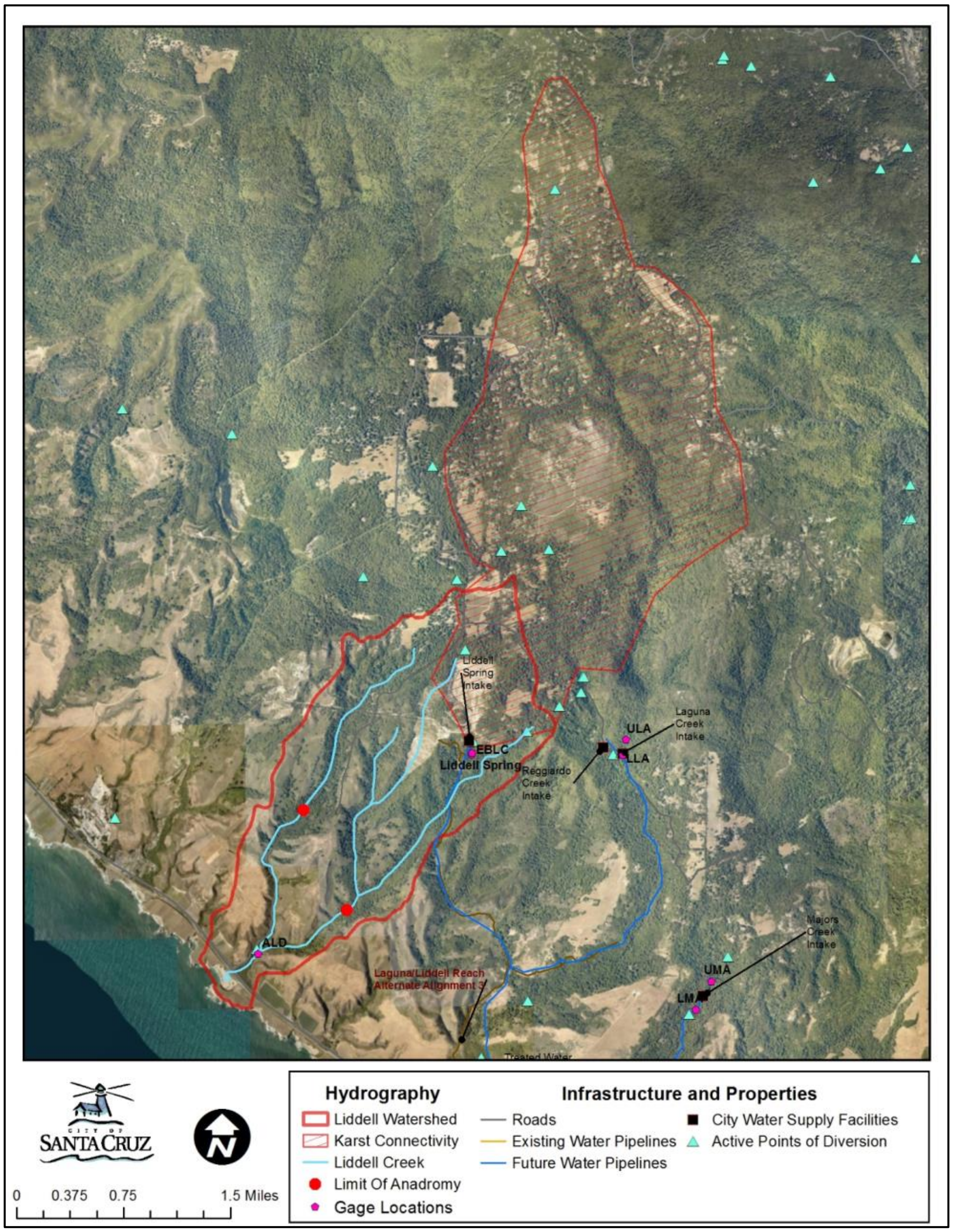


Figure 1-3: Laguna Watershed Map

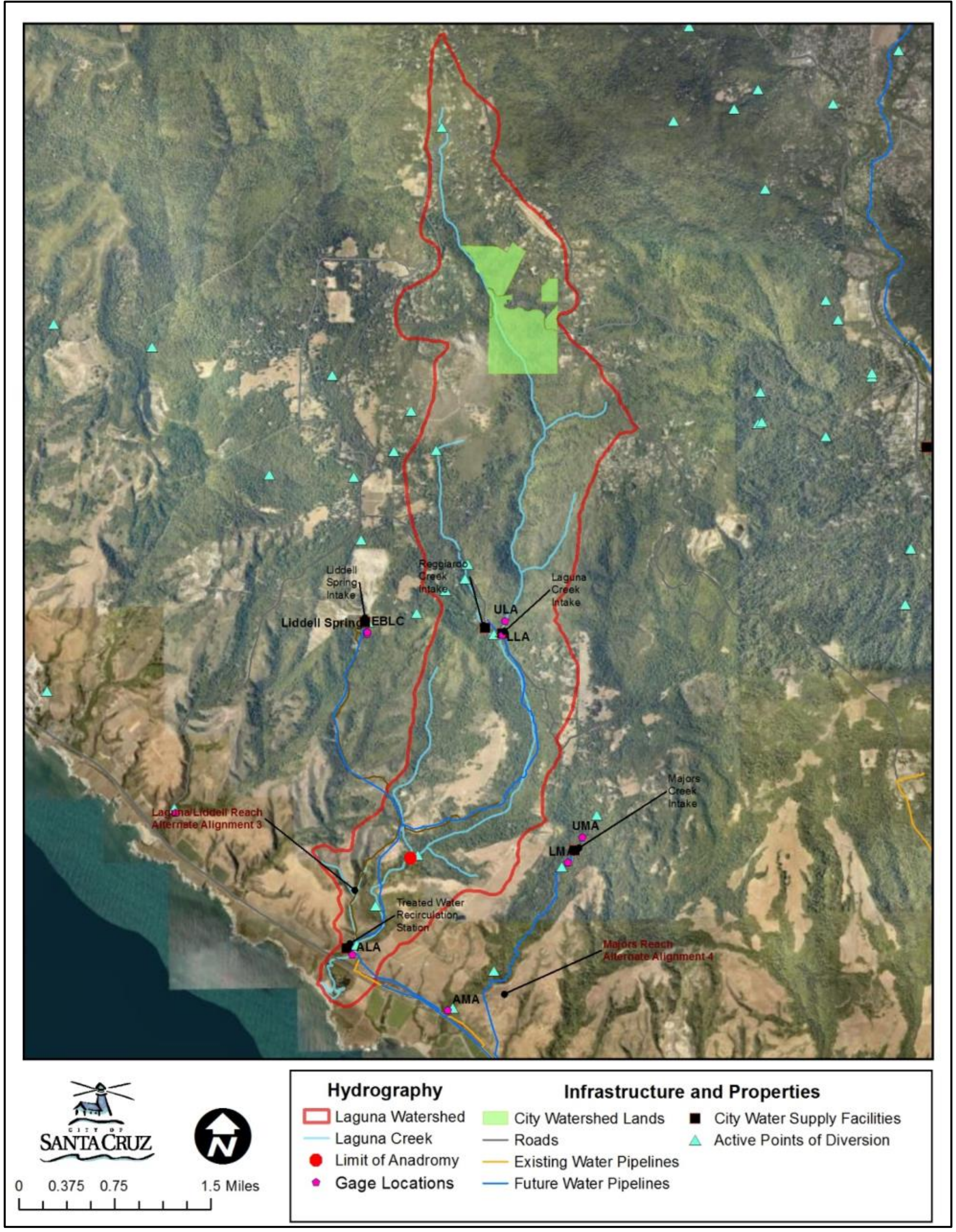


Figure 1-4: Majors Watershed Map

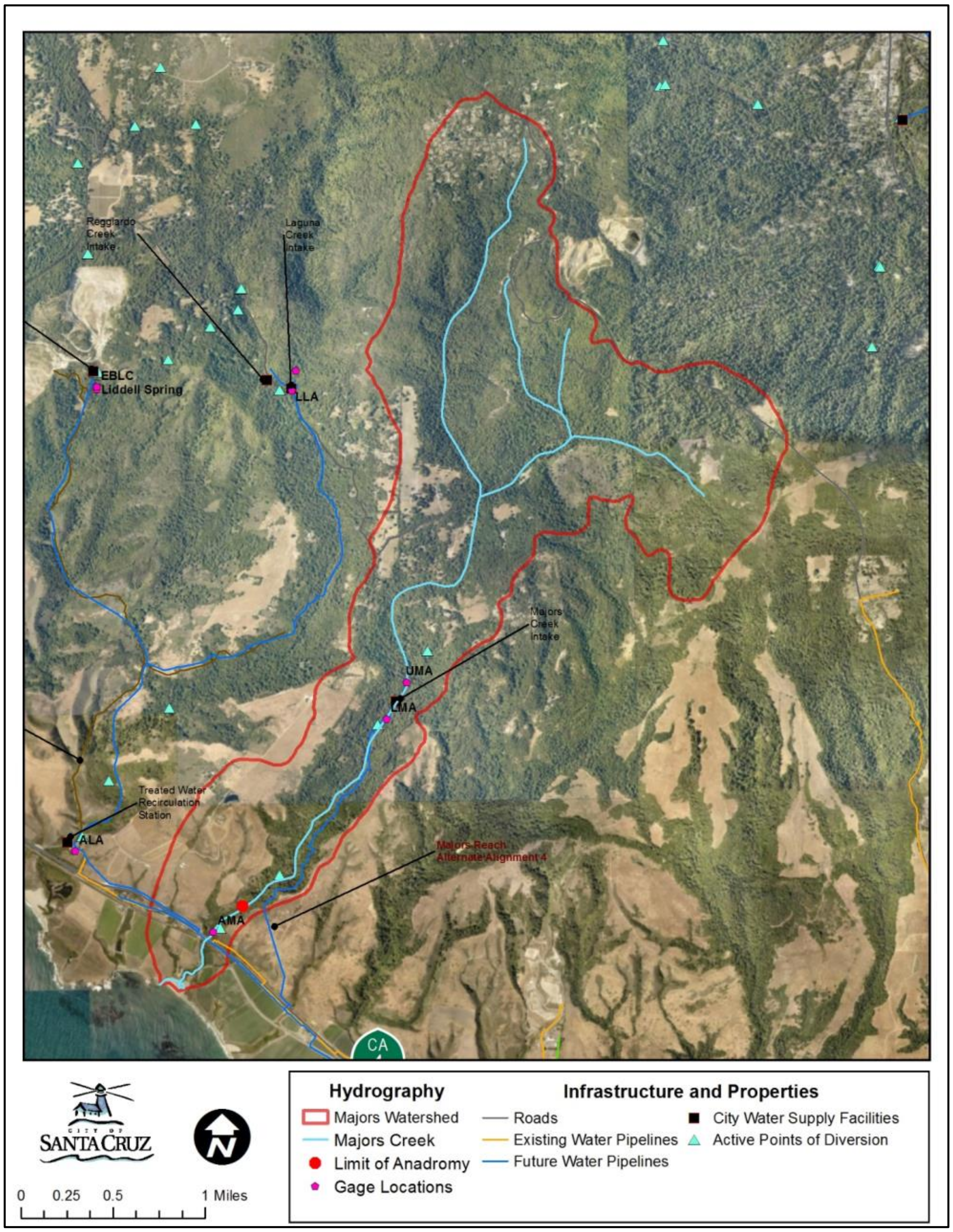


Figure 1-5: Newell Watershed Map

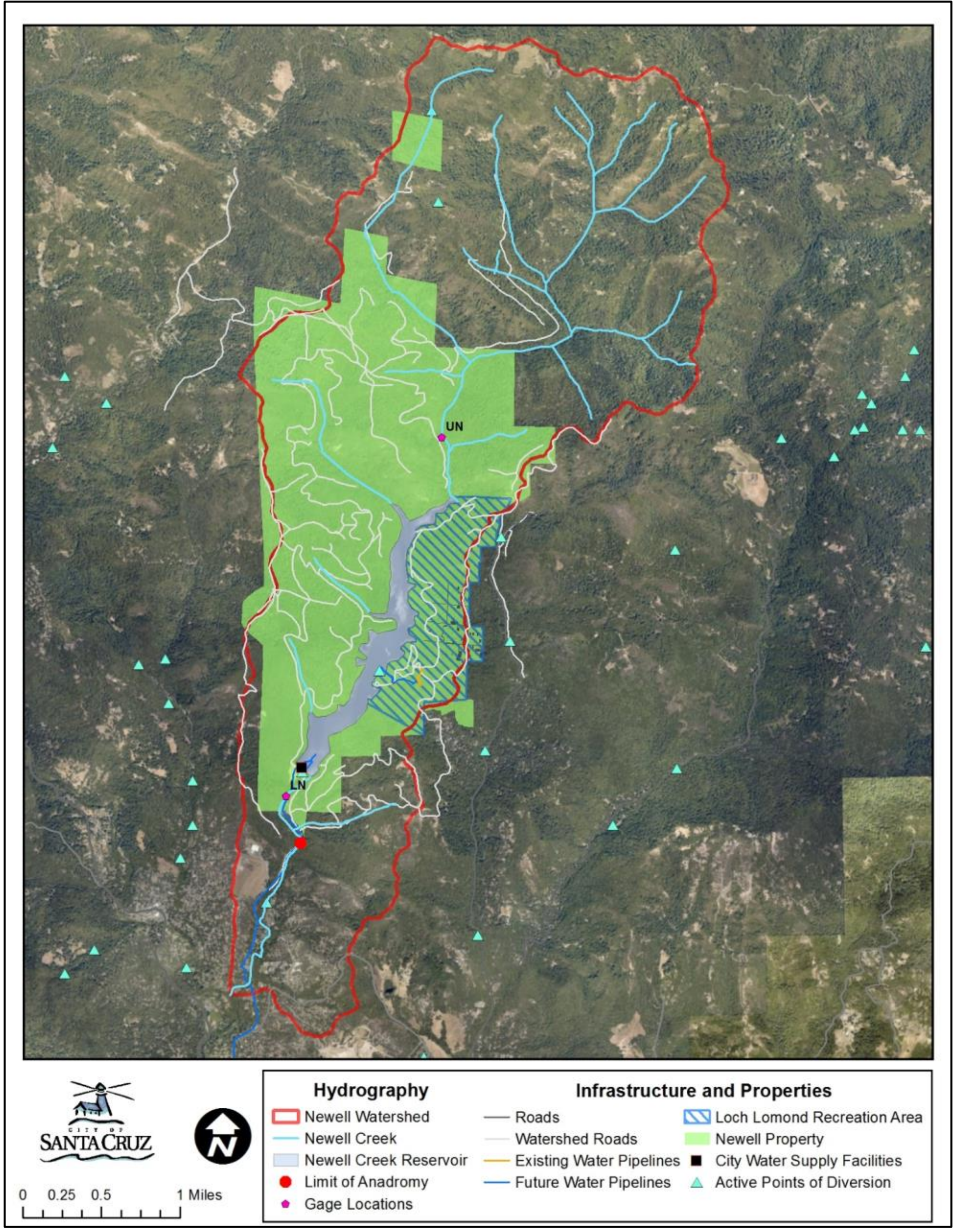


Figure 1-6: Zayante Watershed Map

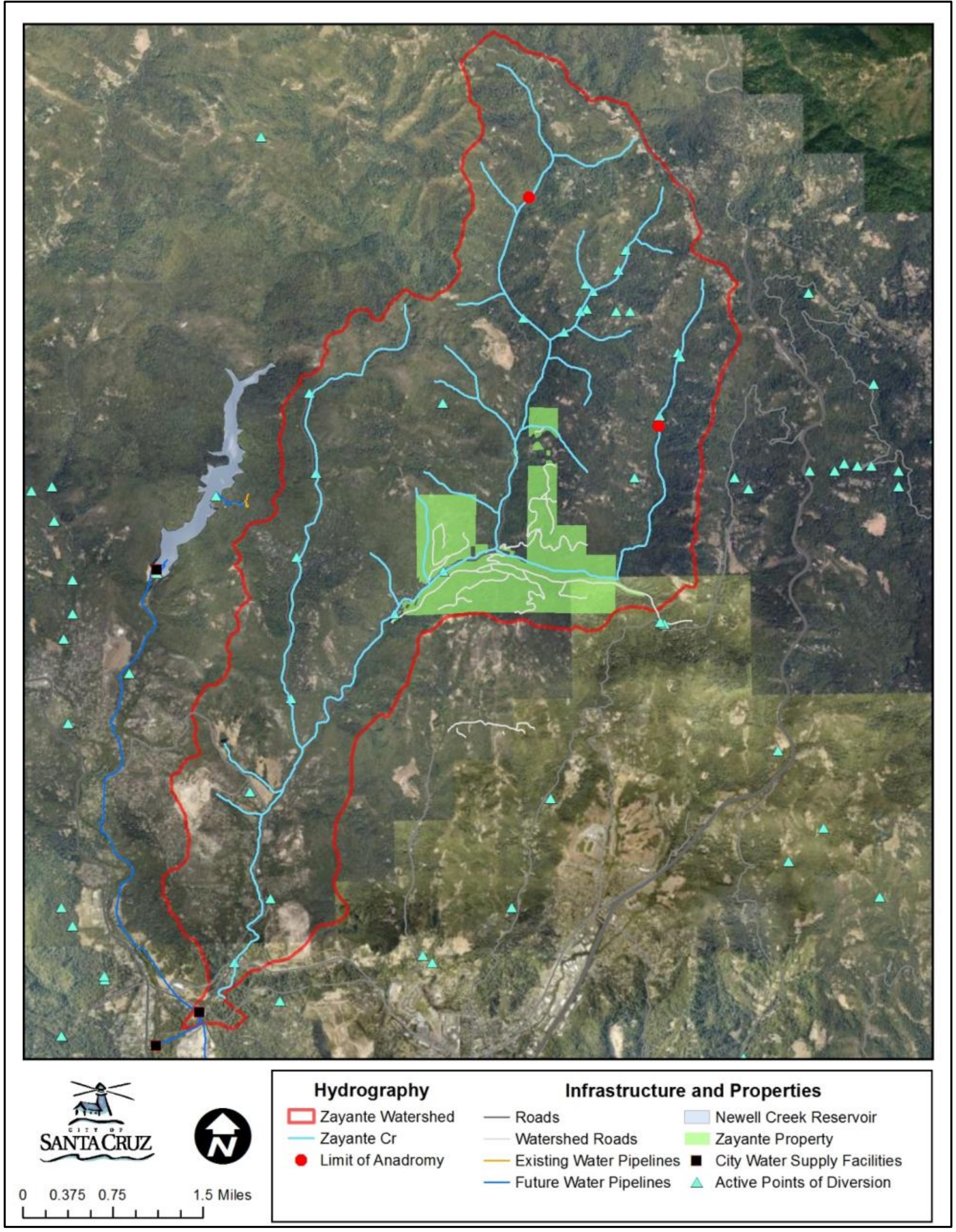
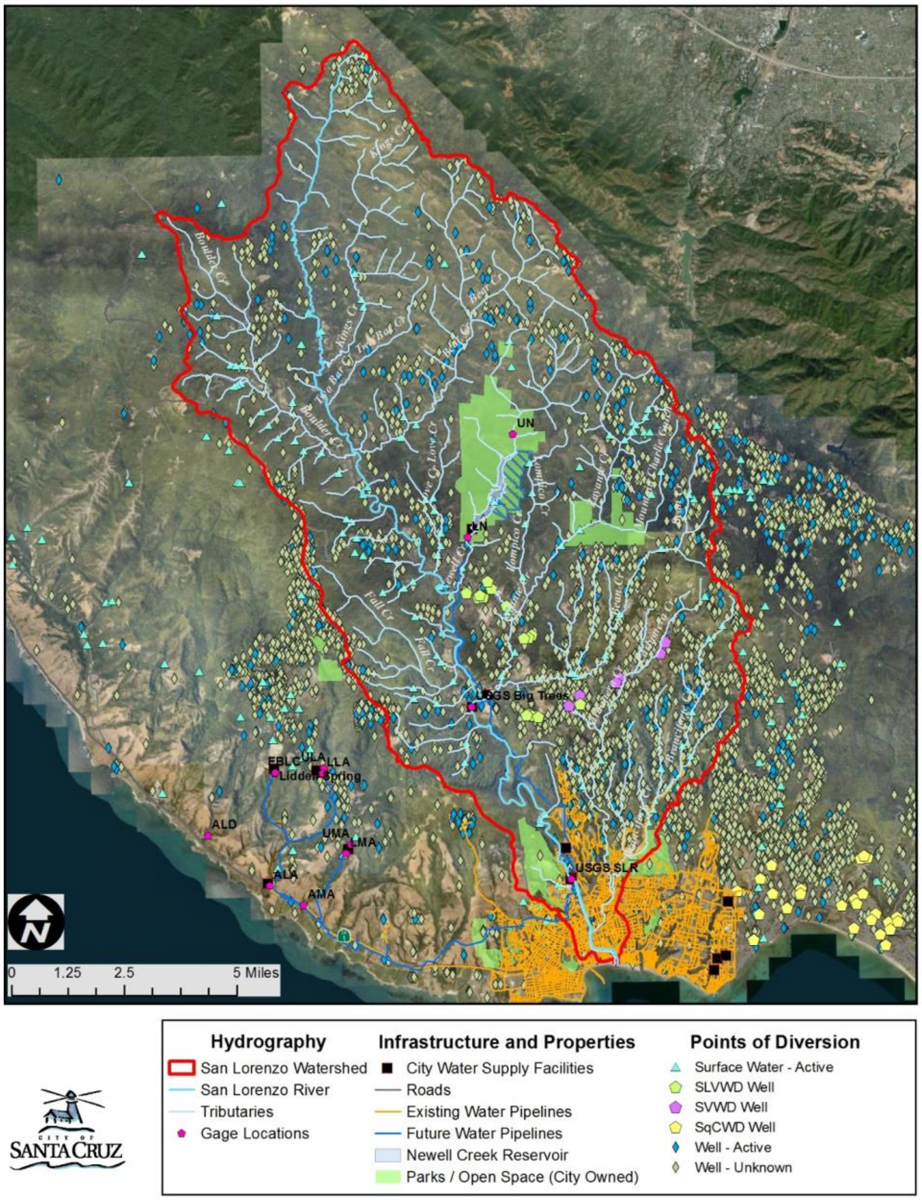


Figure 1-7: San Lorenzo Watershed Map



1.3 HCP Planning Process

The City developed the HCP in close coordination with NMFS and the California Department of Fish and Wildlife (CDFW) over a thirteen-year period.[2] During the initial stage of the process, the parties developed a comprehensive methodology for gathering data on the hydrology and geomorphology of the Plan Area. Following the methodology that was developed, the City conducted extensive field studies of the North Coast streams and the San Lorenzo River to characterize existing habitat conditions.

A major element in the development of the conservation strategy involved identification of minimum in-stream flows at City diversions to minimize the effect of diversions on habitat conditions for the Covered Species, steelhead and coho. The goal was to develop instream flow targets through an iterative process that considered both the habitat values of instream flows as well as the ability of the City to meet its water supply obligations. Instream flow alternatives were modeled using the City's water supply operations model (Confluence® Model) to understand the effect of various flow alternatives on the City's water supply obligations. The City also developed a habitat-based model to analyze the effect that the various flow alternatives would have on Covered Species habitat.

Based on the information developed through field studies and iterative model runs, a Water Supply Advisory Committee (WSAC) convened by the City recommended that the City adopt the flow alternative that was the most protective of the Covered Species and develop a new water supply that would make it practicable for the City to provide the flows for Covered Species while meeting its water supply obligations.

This flow alternative (Conservation Flows)[3] represents a substantial departure from the City's historical operations. Historically, North Coast and Tait Street diversions did not have required bypass flows. Bypass flows at City points of diversions have progressively increased through a tolled streambed alteration agreement process with CDFW since 2007. Conservation Flows included in this HCP entail bypass flows for all points of diversion and an increase in the bypass flow requirement for the Felton Diversion.

Throughout the planning process, the parties continued to meet to address study plans and results, review existing conditions, and develop the various components of the conservation

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[2] CDFW participated in development of the HCP because it has jurisdiction over species listed under the California Endangered Species Act, which includes coho, and because it has jurisdiction over fish and wildlife resources subject to Section 1600 et seq. of the Fish and Game Code, which includes steelhead and coho.

[3] In the City's petitions for changes to water rights, the Conservation Flows are called "Agreed Flows" in recognition that they were developed through negotiations with NMFS and CDFW. The Conservation Flows and the Agreed Flows are identical.

strategy. A comprehensive set of conservation measures was developed by the City to avoid and minimize the effects of City diversions as well as the operations and maintenance activities associated with the City's water supply system. The conservation measures include avoidance and minimization measures including standard operating procedures (SOPs) the City has followed in the past. The conservation measures also include upgrades to City facilities such as fish screens and operational changes to facilities to improve habitat conditions for Covered Species.

To ensure that any effects remaining after implementation of the HCP's conservation measures are mitigated to the maximum extent practicable, the City developed a non-flow conservation program to enhance and restore Covered Species habitat in the Plan Area. The program specifies funding levels and identifies a process for including NMFS and CDFW in technical meetings to identify appropriate habitat enhancement and restoration actions to be funded through the HCP.

1.4 Regulatory Framework

1.4.1 Endangered Species Acts

The United States Congress passed the ESA in 1973 to provide a means for conserving the ecosystems that endangered and threatened species require to prevent species extinctions. The ESA has two major components relevant to this HCP, the Section 9 prohibition against "taking" listed animal species and the Section 10 provisions for permitting the incidental take of listed animal species.

Section 9(a)(1)(B) of the ESA prohibits the "take" by any person of any endangered fish or wildlife species. The ESA authorizes NMFS to prohibit the take of threatened wildlife species through regulation. "Take" is defined broadly to mean harass, harm, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.[4] "Harm" is defined by regulation to mean an act which actually kills or injures wildlife, including those activities that cause significant habitat modification or degradation resulting in the killing or injuring of wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering. The take prohibitions of the ESA apply unless take is otherwise specifically authorized or permitted pursuant to the provisions of Section 7 or Section 10 of the ESA. The protections for listed plant species under the ESA are more limited than for fish and wildlife.[5]

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[4] 16 U.S.C. § 1532 (2020).

[5] Section 9(a)(2)(B) of the ESA prohibits removal, possession, or malicious damage or destruction of endangered plants in areas under federal jurisdiction, as well as actions that remove, cut, dig up, damage, or destroy endangered

The Section 9 take prohibitions apply unless take is otherwise specifically exempted pursuant to Section 7 or authorized pursuant to Section 10 of the ESA. Private individuals, corporations, state and local government agencies, and other non-federal entities who wish to conduct otherwise lawful activities that might incidentally take a listed species must first obtain a Section 10 incidental take permit from NMFS. The contents of a habitat conservation plan must meet the application criteria provided under ESA Section 10(a)(2)(A) and must describe:

- The impact which will likely result from such taking;
- What steps the applicant will take to minimize and mitigate such impacts, and the funding that will be available to implement such steps;
- What alternative actions to such taking the applicant considered and the reasons why such alternatives are not being utilized; and
- Such other measures that the Secretary may require as being necessary or appropriate for purposes of the plan.[6]

Under Section 10(a)(2)(B) of the ESA, NMFS may permit the incidental take of species only after finding that the habitat conservation plan meets the following criteria:

- The taking will be incidental;
- The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking;
- The applicant will ensure that adequate funding for the Plan will be provided;
- The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
- Other measures, if any, which NMFS requires as being necessary or appropriate for purposes of the Plan will be met.[7]

This HCP is intended to meet all regulatory requirements necessary for NMFS to issue a Section 10 permit to allow incidental take of steelhead and coho as a result of Covered Activities undertaken by the City.

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plants in areas outside of federal jurisdiction in violation of any state law or regulation, including state criminal trespass law. Protection for threatened plant species is limited to areas under federal jurisdiction. 50 C.F.R. § 17.71(a). The ESA Section 7(a)(2) prohibition against jeopardy applies to plants, wildlife, and fish equally, and NMFS may not issue a Section 10(a)(1)(B) permit if the issuance of that permit would result in jeopardy to any listed species.

[6] 16 U.S.C. § 1539(a)(2)(A)(2020).

[7] 16 U.S.C. § 1539(a)(2)(B)(2020).

1.4.2 National Environmental Policy Act

The National Environmental Policy Act (NEPA) was enacted by Congress in 1969 to ensure that federal agencies consider the environmental impacts of their actions and decisions.[8] NEPA requires the federal government to use all practicable means and measures to protect environmental values and makes environmental protection a part of the mandate of every federal agency and department. NEPA further requires analysis and a detailed statement of the environmental impact of any proposed federal action that significantly affects the quality of the human environment.

An evaluation in accordance with NEPA will be prepared for the HCP permit decision. The NEPA document will (1) identify the purpose and need for a federal Section 10(a) ITP; (2) describe the environment that would be affected by the proposed Project; (3) discuss alternatives considered; (4) describe plans to minimize and mitigate the impacts to Covered Species and their habitats; and (5) identify possible environmental consequences of the proposed incidental take permit and mitigation measures.

2.0 ENVIRONMENTAL SETTING

2.1 Introduction

This section analyzes the environmental setting within the four regions of the Plan Area (see Figure 1-1: HCP Plan Area). The four regions that constitute the Plan Area are: 1) the North Coast Unit, 2) the San Lorenzo River Watershed Unit, 3) the City Urban Center Unit and 4) the City's water service area outside of the other aforementioned Plan Area regions. The North Coast Unit is located north of the City along Highway 1 and includes Majors Creek, Laguna Creek, Reggiardo Creek, Liddell Creek, and Lombardi Gulch. Streams in the North Coast Unit flow off the west flank of Ben Lomond Mountain and drain directly into the Pacific Ocean. The San Lorenzo River Watershed Unit includes the San Lorenzo River and its major tributaries, including Newell Creek and Zayante Creek. Streams within the City Urban Center Unit are the lower San Lorenzo River and tributaries, and the smaller urban drainages and aquatic resources potentially influenced by Covered Activities, including Neary Lagoon, Laurel Creek, Moore Creek, and Arana Creek. The streams listed under the City Urban Center Unit are located either partially or wholly within the City limits and are influenced by urban land management activities such as vegetation management, flood control and stormwater management activities, rather than or in addition to surface water diversions. Therefore, the lower San Lorenzo River (from the City limits to the river mouth), Branciforte Creek, Carbonera Creek, and Pogonip Creek,

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[8] 42 U.S.C. § 4371 *et seq.* (2020).

although part of the San Lorenzo River watershed, are discussed under the City Urban Center Unit in this HCP. It should be noted that all of the planning units were affected by the recent CZU August Lightning Complex fire to various degrees. While there may be some positive effects of increased wood recruitment to the streams, water quality and stream sedimentation may be negatively impacted by post-fire debris flows. Additionally, there may be some short-term impacts on salmonid respiration and feeding behavior due to increased turbidity related to runoff from the burn zone. The full effects of this event may not be known for some time.

2.2 Climate

The Santa Cruz Mountains, like most of central California, are marked by winter rains and summer drought. Rainy winter periods and dry summer months are typical of the Mediterranean climate in the central coastal areas of California, including the Santa Cruz Mountains. Mean annual precipitation along the coast is about 26 inches but increases to about 50 inches at higher elevations near the headwaters of the project area streams.

Most precipitation falls between the months of November to April, with February typically being the wettest month of the year. Pacific frontal storms in combination with orographic lifting along the coastal range generate intense periods of precipitation. Streams in the project area tend to exhibit “flashy” (rapidly rising and falling) winter flows in response to these winter storms. During the dry season from May through October, the region typically receives no precipitation, the surface soils dry out, and perennial streams are fed by seeps and springs. The western edge of the coast range experiences mild temperatures during the dry season due to the on-shore marine breeze and summer fog.

2.3 Geology

The Plan Area is located in the Coast Ranges geomorphic province. This northwest-trending, 900-mile-long province contains mountain ranges and associated intervening valleys that are relatively comparable in age and share somewhat similar history, geologic composition, and structure. The Santa Cruz Mountains, part of which are included in the Plan Area, represents one of these ranges. This mountain range forms the mountainous spine of the San Francisco Peninsula and extends about 80 miles, from the vicinities of Daly City to Watsonville. The average summit height reaches 2,500 feet above sea level. The Coast Ranges are considered very seismically active due to the abundance of active faults. The San Andreas and San Gregorio fault zones represent the two principal active faults within the region (Hall et al. 1974; Hart and Bryant 1997).

2.3.1 North Coast Unit

The Coast Ranges typically exhibit strong northwest-southeast trends, induced by folds and faults of the same trend. This complex presumably formed as a result of the subduction of the western oceanic plate beneath the continental plate beginning in the Mesozoic Period.

The three North Coast source streams drain the southwest side of Ben Lomond Mountain. Ben Lomond Mountain is a large mass of granitic rock that was uplifted and tilted to the southwest by the Ben Lomond fault, which parallels the San Lorenzo River Valley for much of its length. The granitic rock that forms the core of Ben Lomond Mountain is locally overlain by relatively thin deposits of metamorphic and sedimentary rocks (Nolan Associates 2016). These deposits are dominated in much of the watersheds by sandstones, mudstones, shale, and coastal terrace deposits (Brabb et al. 1997). These deposits generate less-dense substrate in stream beds and can contribute to high sand loads as is evident in all three creeks to varying degrees. The less dense sandstone and mudstone elements provide less suitable spawning substrate than heavier granitics as they are more easily mobilized under high flow conditions.

A large portion of the Majors Creek watershed is underlain by the Santa Margarita formation, which is composed of friable, fine to very coarse-grained sandstone (Brabb et al. 1997). The majority of the watershed upstream of the City’s diversion is privately held and was historically logged for timber production. Old logging roads remain in several places in the watershed. These factors likely contribute to high fine sediment loads evident throughout the Majors Creek system. About 2,000 feet below the City’s diversion, Majors Creek begins flowing through a zone dominated by igneous, Quartz diorite rock. The Quartz diorite is more resistant to erosion relative to other rocks within the North Coast Unit, and leads to a more confined, steep valley wall section with a high gradient. It may also serve as a good source of gravel, which was evident in the anadromous reach during habitat characterization conducted in 2003 (Entrix 2004b).

The Middle and East Branch Liddell watersheds are primarily (76 percent) composed of tertiary marine sedimentary rocks. The Santa Cruz Mudstone makes up about 48 percent of the Middle and East Branch basins and is composed primarily of silica-rich mudstones and sandy siltstones. About 26 percent of the watersheds are made up of the Santa Margarita sandstone, and the majority is concentrated in the upper East Branch watershed. The Santa Margarita formation consists of massive fine to coarse-grained arkosic sandstones with poor cementation of the sand grains. The Santa Margarita formation is weak and friable, and very erodible once the overlying soil layer is removed. The channel on the East Branch contains large amounts of fine sediment, and bed particles have an average 85 percent embeddedness (Environmental Sciences Associates 2001), which in part can be attributed to the large amount of highly erosive Santa Margarita sandstone (Entrix 2004b).

Limestone and marble outcroppings, commonly referred to as karst topography, occur in the upper reaches of Liddell and Laguna Creeks (Nolan and Associates 2016, Brabb et al. 1997). The karst topography has a significant influence on streamflow and summer baseflow by producing multiple springs within the watersheds. The karst topography is also more resistant to erosion than other material in nearby watersheds, which results in reduced fine sediment loads. The upper part of the Laguna watershed also has granitic formations that provide a good source of gravel and cobble. This is evident in the reaches downstream of the City’s diversion where large cobble and gravel dominate the streambed substrate (Entrix 2004b).

A distinctive geomorphic feature of the lower watersheds in the North Coast area are the marine terraces (and associated deposits), which were formed in the past when the sea level was higher relative to the current sea level (Brabb et al. 1997). These flat, wave-cut platforms were formed primarily in the sandstone and mudstone sedimentary layers mentioned above. The marine terraces were created by the interplay between the constant erosive force of waves combined with the fluctuating sea level stands of the Pleistocene (1.8 million years ago to 10,000 years ago), glacial and interglacial cycles and the slow uplifting of the coastline. Each marine terrace is a former part of the continental shelf that has been cut by the waves over many millennia, then uplifted above sea level into its present position (Entrix 2004b).

2.3.2 San Lorenzo River Watershed Unit

In the San Lorenzo River Watershed Unit, two primary fault systems define the geologic conditions: the Zayante fault and the Ben Lomond fault. The Zayante fault trends primarily east to west through the middle of the San Lorenzo River basin. The Ben Lomond fault trends primarily north to south on the west edge of the basin along Ben Lomond Mountain. The two faults intersect near Jamison Creek in the northwest area of the basin. The two faults divide the San Lorenzo Valley into three terrains: (1) north of the Zayante fault, (2) south of the Zayante fault and west of the Ben Lomond fault, and (3) south of the Zayante fault and east of the Ben Lomond fault. The following descriptions of these terrains are derived from Balance Hydrologics (Hecht and Kittleson 1998) report on streambed conditions and erosion control efforts in the San Lorenzo River watershed.

North of the Zayante fault, interbedded sandstones, shales, and mudstone predominate, with steeply inclined and folded strata. Complex mosaics of soils and vegetation have developed on these geologic structures, resulting in diverse and widespread sediment sources. Slopes tend to be steep, prone to moderate to severe erosion. Principal watersheds are the upper San Lorenzo River (above Boulder Creek), Kings, Two Bar, and Bear Creeks, plus the northern portions of the Boulder Creek and Zayante Creek basins. The Butano fault, which runs parallel and to the north of Zayante fault, once brought hard sandstones upward, resulting in a very steep slope rising from the River and Bear Creek abruptly toward the Summit ridge. This zone between the Butano fault and the Summit is now a belt of often-serious erosional sources, as roads and clearings are cut through this over-steepened slope. Dry-season flows are generally lowest in this geologic terrain, with streams often drying to isolated pools during mid-summer.

South of the Zayante fault, and west of the Ben Lomond fault, the tectonically uplifted eastern side of Ben Lomond Mountain forms the southwestern edge of the San Lorenzo watershed. Principal watersheds are Fall, Alba, Clear and Sweetwater creeks, Malosky, Peavine, and Jamison creeks, and the southern portion of the Boulder Creek basin. Crystalline bedrock types, principally granitics, schists, and marble, have developed residual soils which support steep small forested watersheds with low to moderate background erosion rates. Streams clear up quickly after storms. The lower portions of these watersheds have developed in downslope-dipping sandstones and mudstones and are prone to landslides, especially where disturbed. Summer flows are generally sufficient to support perennial stream threads and diverse aquatic habitat.

The third terrain is found south of the Zayante fault, and east of the Ben Lomond fault and the San Lorenzo River. It includes the Love Creek, Quail Hollow, Graham Hill Road, Mount Hermon, and Scotts Valley areas, as well most of the Bean and Branciforte Creek basins, and the southern portions of the Zayante and Newell Creek watersheds. Here, sandstones and shales form erodible soils which tend to be either very sandy or clay rich. Much of the area was once vegetated with unusual associations of trees and shrubs that exploited niches made available by these atypical soils. By far the largest continuous units of sandy soils are found in this area, and these tend to be sandier than other sandstone-derived soils elsewhere in the watershed. Erosion rates are often high to extreme in this terrain, especially where sandy soils occur in headwater areas or near channels. The sandy soils, which were capable of absorbing nearly all rainfall under natural conditions, now form steep-walled gullies and gulches where runoff from paved or covered surfaces is concentrated.

2.3.3 City Urban Center Unit

The geologic description of the City Urban Center is based on the City-Wide Creeks and Management Plan prepared by the Biotic Resources Group (2002). The City of Santa Cruz can be divided fairly evenly into two geologic regimes split roughly at the San Lorenzo River where the Ben Lomond fault trends southeast to northwest. The geology on the west side of the San Lorenzo River is composed of a mix of granitic and metamorphic basement rocks overlain by a relatively thin layer of sedimentary rocks. The underlying geology on the east side of the San Lorenzo River, like the west side, is composed of a mix of granitic and metamorphic basement rocks. The east side basement rocks are overlain by a thick layer of sedimentary rocks and marine terraces up to hundreds of feet deep.

Most of the City of Santa Cruz sits primarily on marine sedimentary rocks, mainly sandstones and mudstones. These include the Purisima formation, which is a fine-grained sandstone formation that was deposited approximately two to six million years ago in a shallow marine environment. The slightly older Santa Cruz Mudstone formation is an even finer-grained silt/mud stone that was also deposited in a shallow marine or estuarine environment. Both of these formations underlie much of the City. Higher in elevation, particularly on the UCSC campus, other sedimentary formations such as limestone as well as the aforementioned metamorphic and igneous formations, begin to appear in outcroppings.

The San Lorenzo River and the other watercourses in the City incise the step-like series of marine terraces that typify the North Coast region. Much of the City sits upon the “first” marine terrace, typified by the flat areas that most of the westside and eastside neighborhoods sit upon. Above that is the “second” marine terrace, typified by the Westlake Pond area and the base of the UCSC campus and also the DeLaveaga Park area on the eastside. Several additional marine terraces are discernable higher up on the UCSC campus. The downtown area of the City lies below the first marine terrace, within the floodplain of the San Lorenzo River, and is underlain by an approximately 40-foot-deep layer of sediments that has been deposited by the San Lorenzo River over many centuries on top of another wave-cut marine terrace.

2.4 Aquatic Habitat

2.4.1 Introduction

This section summarizes and describes the existing environmental conditions relevant to steelhead and coho in streams within the North Coast Unit, the San Lorenzo River Watershed Unit, and the City Urban Center Unit of the Plan Area.

2.4.2 North Coast

The following discussion describes conditions in North Coast streams, including Liddell, Laguna, and Majors Creeks.

2.4.2.1 Habitat Conditions Liddell Creek

Liddell Creek supports resident rainbow trout populations and steelhead. Liddell Creek is not considered potential habitat for coho under current conditions in the Coho Recovery Plan (NMFS 2012). Three young-of-year (YOY) coho were observed in Liddell Creek in 2018, the first observation of *O. kisutch* in Liddell Creek since sampling began in 2006 (Berry et al. 2019). These fish are considered the progeny of strays from another system, likely nearby Scott Creek, and are not thought to represent a persistent population. For the purposes of the HCP, Liddell Creek is not considered potential coho habitat.

Watershed/hydrology

Liddell Creek is a second order stream that enters the Pacific Ocean at Bonny Doon Beach directly south of Davenport. The 4.0 square mile watershed drains in a southwest direction off of Ben Lomond Mountain (ENTRIX, Inc. 2004b). The elevation of the watershed ranges from sea level at the mouth to approximately 1,300 feet at its headwaters near Smith Grade Road. Liddell Creek consists of three distinct forks, the Middle, East, and West branches (see Figure 1-2: Liddell Watershed Map). The approximate stream channel length from the mouth of Liddell to the mainstem Liddell Creek headwaters is 3.2 miles. The channel gradient from the diversion to the mouth is approximately 3 percent along the East Branch of Liddell Creek (ENTRIX, Inc. 2004b).

Natural streamflow in Liddell Creek is influenced by the karst topography. Approximately 11 percent of the Middle and East Branch Liddell watersheds are composed of marble (metamorphosed limestone) outcrops (ENTRIX, Inc. 2004b). This results in more stable streamflows and higher summer baseflows in Liddell Creek compared to Laguna and Majors Creeks. Streamflows are also influenced by diversions in the watershed.

The City diversion on Liddell Spring has a maximum capacity of approximately 2.5 cubic feet per second (cfs) and is located at a springbox on a tributary to the East Branch of Liddell Creek near its headwaters, approximately 2.5 miles upstream from the mouth (ENTRIX, Inc. 2004b). There have been no specified limits on diversion rates or quantities and a bypass flow has not been required at the diversion under the water right, though “tolling flows” which are protective of anadromous fisheries and which were developed with CDFW have been in place for several years. Proposed bypass flows under the HCP are described in Chapter 4. While the City diverts a significant portion of the flow in Liddell Creek, due to the distance to the anadromous reach and the accretion from tributaries downstream, the effect of the City's diversion on instream flows is muted relative to the City's other North Coast water supply streams. CEMEX (previously RMC Pacific Materials) operated a diversion located just upstream of the City's springbox diversion on a tributary to East Liddell Creek to support their quarry operations. The quarry is not currently in use, however a new industrial use is occupying the site and is routinely using this diversion. This diversion produced approximately 300 gallons per minute when it was operating under CEMEX (approximately 0.67 cfs) (Chris Berry, personal communication to Kindra Loomis, 2004, cited in ENTRIX, Inc. 2004a) and now appears to be diverting approximately 150 gallons per minute when it is in operation. Potentially, there are also other private diversions and numerous wells upstream in the recharge area for this creek (Chris Berry, personal communication to Kindra Loomis, 2004, cited in ENTRIX, Inc. 2004a). The City maintains control of all riparian water rights downstream of its diversion so the wells adjacent to the anadromous reach would be operating without water rights. In the lower watershed there are alluvial wells operated by The Coast Dairies and Land Co.[9] and an agricultural diversion of unknown status (ENTRIX, Inc. 2004b). Production volumes of these wells and their impacts on the hydrology and associated aquatic habitat in Liddell Creek are unknown. The City maintains control of all riparian water rights downstream of its diversion so the wells adjacent to the anadromous reach would be operating without water rights. Additionally, e-WRIMS filing status for these wells and for the quarry spring appear to be incomplete. This may not be a comprehensive accounting of the non - City operated diversions on Liddell Creek (ENTRIX, Inc. 2004b).

The lower portions of the East Branch Liddell Creek are characterized as having riffle-pool channel morphology with open valley walls (ENTRIX, Inc. 2004b). Large woody debris plays a significant role in shaping channel morphology as debris jams are prevalent throughout the East Branch. Debris jams also form multiple obstacles or partial barriers to anadromous fish migration (ENTRIX, Inc. 2004b). On the East Branch above these obstacles the channel becomes more confined, has a slightly steeper gradient, and is a combination of step-pool and riffle-pool channel morphology (ENTRIX, Inc. 2004b). The channel substrate on the East Fork is a mixture of sand, cobble, and gravel. There are large quantities of fine material on the channel bed throughout the East Branch that are related to the sedimentary geological characteristics and human activity, including the marble and limestone quarry previously operated by CEMEX that is located in the upper portions of the East Branch of Liddell Creek (ENTRIX, Inc. 2004a, ENTRIX, Inc. 2004b). Sedimentation ponds at the quarry, a conveyor belt transporting crushed limestone and marble, and quarry access roads all contributed a substantial amount of fine-grained sediment to each of the three branches resulting in 100 percent substrate embeddedness in several areas (Environmental Sciences Associates, 2001,

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[9] Coast Dairies and Land Co. land is now owned and managed by California State Parks and the Bureau of Land Management.

ENTRIX, Inc. 2004a, Entrix, Inc. 2004b). Road and bank failures along Bonny Doon Road are also reported to be partially responsible for the relatively high levels of fine sediment in the Main Branch (Environmental Sciences Associates 2001 cited in ENTRIX, Inc. 2004a). Recent sediment analysis at Liddell Spring indicates sourcing from the CEMEX quarry (Strudley and Chartrand 2010).

Instream Habitat

Liddell Creek downstream of the west branch and in the east branch has good, dense riparian cover but poor instream habitat due to lack of pool development and shallow depths resulting from accumulations of sand (Hagar 2005). In many places, instream structures such as large woody debris are present but do not form scour pools due to the high sand load. Large amounts of sand are impounded behind many log debris jams. The stream is very narrow and confined, partly as a result of the karst topography with more seasonally stable streamflows and without extreme winter flows that would scour a wider active channel. Habitat in the West Branch is comparable to the East Branch though the West Branch is a slightly smaller stream. The East Branch contributes the majority of dry season flow below the confluence of the East and West Branches (Entrix 2004b).

Migration Barriers

The upstream limit of anadromy in Liddell Creek is a natural migration barrier formed where the stream passes over a bedrock ledge about 1.16 miles upstream from the mouth and 0.13 miles downstream of the confluence of the East Branch with the Middle Branch (Hagar et al. 2017a).

There are numerous obstacles to migration in the anadromous reach of Liddell Creek. Migration issues begin at the mouth where the channel was filled in the late 19th Century to create an earthen causeway for a rail and roadway (Highway 1) transportation corridor. The stream was rerouted through a bedrock bore on the north side of the stream valley. The causeway is immediately behind the beach berm, and together with forcing the stream through the bedrock bore, impairs processes that would form a lagoon and results in lack of significant lagoon formation at the mouth of the creek. The outfall of the bedrock bore contains two concrete barriers that partially close the opening (ENTRIX, Inc. 2004a). This crossing may pose a passage problem to migrating salmonids in certain hydrologic conditions (HC) such as during the winter when the beach sand is scoured away and a vertical drop of up to 3 feet (with no significant plunge pool) forms at the culvert exit point (Environmental Sciences Associates 2001 cited in ENTRIX, Inc. 2004a). This condition is transient as conditions suitable for passage have been observed at this location on occasion (Chris Berry, personal communication to Jeff Hagar, 2006).

There is a concrete apron at the upper end of the bedrock bore associated with causeway. Under low flow conditions the cross-section of the apron results in a wide shallow channel with insufficient depth for passage of steelhead. A minimum flow of 8.1 cfs is needed to meet passage criteria for adult steelhead at this location and a flow of at least 2.0 cfs is required for downstream migration of steelhead smolts (HES 2014b). Without City diversions, a flow of 8.1 cfs is equaled or exceeded in Liddell Creek about 32% of the time in January, a peak month for adult steelhead migration. During the end of the peak smolt outmigration period in May, a flow of 2.0 cfs is equaled or exceeded about 98% of the time with no City diversions (Historical Hydrology Database - Water Years 1938-2015, Balance Hydrologics, Inc. 2020).

Bonny Doon Road runs adjacent to the Main and West Branches of Liddell Creek for approximately 1 mile upstream of Highway 1. Three culvert road crossings of the West Branch exist in this reach. All three were given a priority ranking of “high” in the County of Santa Cruz Stream Crossing Inventory and Fish Passage Evaluation (Ross Taylor and Associates, 2004). Passage problems are related to severe under-sizing of the culverts and a perched outlet at the lowermost crossing that likely impedes most migration attempts for both adult and juvenile steelhead (Ross Taylor and Associates, 2004). The middle culvert was replaced in 2003 and is no longer considered a passage barrier (K. Kittleson, County of Santa Cruz, personal communication to Jeff Hagar, January 15, 2020). The upper and lower culverts were re-evaluated as low priority due to poor passage at the Highway 1 bedrock bore and re-evaluation of habitat upstream of the upper culvert as fair/poor (Kittleson 2015).

Under low flow conditions, even riffles and other shallow cross-sections (such as the Highway 1 culvert aprons) may hinder migration of adult salmonids. Critical riffles are riffles with the widest, flattest cross-sections requiring the most flow to achieve sufficient depth for passage. Passage depth criteria for adult steelhead are not met at flows less than 11.3 cfs at critical riffle cross-sections in the anadromous reach of Liddell Creek (HES 2014b). The passage depth criterion for adult steelhead is a depth of at least 0.6 feet continuous across at least 10% of the cross-section (Thompson 1972, CDFW 2012). A flow of at least 2.0 cfs is required to meet downstream passage criteria for steelhead smolts at critical riffles in Liddell Creek (HES 2014b). More information on passage flow determination is provided in HES (2014b) (Appendix 3: *Flow Studies*).

The natural hydrology (without City diversions) produces conditions that meet migration needs of adult steelhead for a significant amount of time during the migration season (December through April) in normal and wet years (Chapter 5). On average there are over 120 days during the migration season with flow meeting migration criteria in wet years and over 90 days in normal years. In dry years migration opportunities are lower with about 40 days meeting the criteria and in critical years there are 15 days with flows meeting migration criteria. Operation of the City diversion has reduced the frequency of suitable migration conditions, particularly in normal and dry years (Chapter 5). Bypass flows implemented as part of the HCP substantially restore migration opportunities in normal and wet years (Chapter 5). Suitable flow conditions for steelhead smolts exist most of the time without City diversions with 140 days or more in all hydrologic year types during the January to May potential smolt migration period (Chapter 5). City diversions have substantially reduced the amount of time with suitable smolt migration flows in dry and critical years during past operations. Bypass flows under the HCP will result in some improvement (Chapter 5).

Spawning Habitat

Substrate in the Liddell Creek watershed is primarily derived from the easily mobilized Santa Cruz mudstone and Santa Margarita sandstone formations, which result in numerous fines and lower-density gravels than those derived from granitic sources in the Laguna and Majors watersheds (ENTRIX, Inc. 2004a). About 25 percent of the Liddell Creek watershed consists of the Santa Margarita sandstone. As a result, large amounts of fine sediment and high degrees of embeddedness are common throughout the anadromous reach of Liddell Creek and limit the potential spawning habitat. This is especially true of the Main Branch reaches. Embeddedness reported by Environmental Sciences Associates (2001) (cited in ENTRIX, Inc. 2004a) in the Main Branch ranged from 40 to 95 percent and on the West Branch from 30-65 percent. Environmental Sciences Associates (2001) suggested that redds may have a high sand content and redd destruction from scouring is common (ENTRIX, Inc. 2004a). In some years (e.g., 1983) late spring storms may either have destroyed redds or caused severe mortality among recently emerged fry (Environmental Sciences Associates 2001 cited in ENTRIX, Inc. 2004a). Of the anadromous reaches, the lower reach of the West branch had substantially less fine sediment relative to the other reaches studied, increasing the quality of spawning gravels (Environmental Sciences Associates 2001 cited in ENTRIX, Inc. 2004a).

During a spawning flow assessment in the winter of 2006-2007, HES located four study sites in potential spawning habitat in the anadromous reach (HES 2014b). Sites were selected to represent locations with good spawning potential based on micro-habitat, hydraulic, and substrate characteristics. Substrate at these sites was generally rated as only moderately suitable based on the Bovee system.[10] Three of the sites had a few cells with moderate to high substrate suitability ratings but only one of the four sites had consistently high ratings across the channel.

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[10] This method of substrate coding (Bovee 1978) uses a single digit (corresponding to particle size) and a decimal (corresponding to abundance). The two-digit code describes the mixture of the two adjacent-sized particle classes which dominate a particular cell by assigning the number (1 through 8 as in Table 2-1) of the smaller-diameter size class to the digit place and the volumetric percentage (0 through 9 for 0% to 90%) of the larger-diameter size class to the decimal place.

Substrate at these sites was quite variable but consisted primarily of sand/gravel mixtures with relatively high proportions of sand. Lower suitability ratings were generally the result of excessive sand. Cobble size substrate was an infrequent component of the streambed in Liddell Creek.

Table 2-1: Substrate Size Class Coding Using the Bovee System

Substrate Size Code	Substrate Size Range
1	Organic debris or vegetation
2	Mud or soft clay (<0.002")
3	Silt (<0.002")
4	Sand (0.002"-0.25")
5	Gravel (0.25"-3.0")
6	Cobble/Rubble (3.0"-12.0")
7	Boulder (>12.0")
8	Bedrock

For steelhead in Liddell Creek the spawning suitability index[11] is high (at least 80% of the peak value) across a very broad range of flow between 7.4 and 24.6 cfs with a peak at about 13.7 cfs (HES 2014b). Suitability of spawning habitat is highest during wet years and declines with drier conditions to about half the wet-year value in critically dry years (Chapter 5). Operation of the City diversion has historically resulted in lower spawning habitat values than would have occurred without the diversion (Chapter 5). Conservation Flows implemented as part of the HCP will result in some improvement relative to historical operation, particularly in wet and normal year types (Chapter 5).

Rearing Habitat

Habitat quality for rearing steelhead in Liddell Creek is fair to poor. Canopy is relatively dense and overhanging terrestrial vegetation provides cover in many locations (ENTRIX, Inc. 2004a, Hagar 2005). Good, dense riparian cover in the form of downed tree trunks, branches, and roots is present, however the large amount of sand substrate limits its utility as cover. Even where objects such as root masses, large woody debris, and bedrock ledges are located in a good position to cause scour of sand and formation of pools, these structures are largely buried in sand

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[11] The relationship between flow and spawning habitat quality for steelhead was assessed using the Physical Habitat Simulation (PHABSIM) model of the Instream Flow Incremental Methodology (Bovee et al. 1998). The spawning habitat assessment was completed by measuring hydraulic conditions at sites in the anadromous reach of Liddell Creek and constructing computer models to predict changes in suitability of water depth, velocity, and substrate with discharge. The PHABSIM model development and use is described in a separate report (HES 2014b).

and there is often very little associated pool development (Hagar 2005). Riffle habitat is also limited, estimated at just 18% by stream length (ENTRIX, Inc. 2004a). This, together with the extensive sandy substrate may limit formation of a healthy benthic macro-invertebrate forage base for steelhead juveniles. Habitat is more limited in the East Branch upstream of the West Branch confluence than downstream of the confluence (Hagar 2005). Limiting factors for rearing steelhead would include pool depth, cover, substrate, and flow, in that order (Harvey & Stanley Associates 1982).

Habitat suitability for rearing steelhead in Liddell Creek increases gradually as flow increases from minimum levels and levels oat at a flow of 14 cfs and higher (HES 2014b). A flow of 5.2 cfs provides 80% of the rearing index[12] for steelhead as that provided at a flow of 14 cfs. Streamflow during the dry season falls well below these levels. Streamflow is most limiting for rearing during the spring and summer and during dry and critically dry years. Without City diversion, habitat value for rearing steelhead in Liddell Creek declines in summer (defined here as July-September) to about 80% to 90% of spring levels (defined here as April-June) depending on year type (Chapter 5). In wet years, the decline is greater and in critically dry years it is less. Spring flows in critical years are about 70% of those in wet years while summer flows in critical years are about 80% of summer flows in wet years. The effect of the City diversion is to reduce spring habitat values up to 30% on average in critical years and to reduce summer habitat values by up to 40% on average in critical years (Chapter 5).

The dense riparian canopy in Liddell Creek and the marine influence on this coastal watershed result in good water temperature conditions for salmonids. Steelhead are generally expected to survive and grow well at temperature up to about 19°C to 21°C if food is abundant. Temperature of 19°C or less is considered optimal under most conditions (Bidgood and Berst 1969, Hokanson et al. 1977, Smith and Li 1983, Armour 1991, see also HES 2014b for a summary of these findings). Steelhead may actually grow faster at higher temperatures if food is abundant (Smith and Li 1983) but at temperature in excess of 21°C, increased mortality may offset the benefits of increased growth rates at the population level Hokanson et al. 1977 (see HES 2014b for discussion of temperature suitability). Temperatures of 25°C to 26°C are generally considered lethal (Bidgood and Berst 1969, Hokanson et al. 1977). Temperature monitoring at the anadromous gage site indicates that, during the summer period, 15-minute water temperature

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[12] The relationship between flow and rearing habitat quality for steelhead was assessed using the Physical Habitat Simulation (PHABSIM) model of the Instream Flow Incremental Methodology (Bovee et al. 1998). The rearing habitat assessment was completed by measuring hydraulic conditions at sites in the anadromous reach of Liddell Creek and constructing computer models to predict changes in suitability of water depth, velocity, and substrate with discharge. The PHABSIM model development and use is described in a separate report (HES 2014b, Appendix 3: *Flow Studies*).

averages around 14°C with a maximum around 16°C[13] (City of Santa Cruz monitoring data, Figure 2-1).

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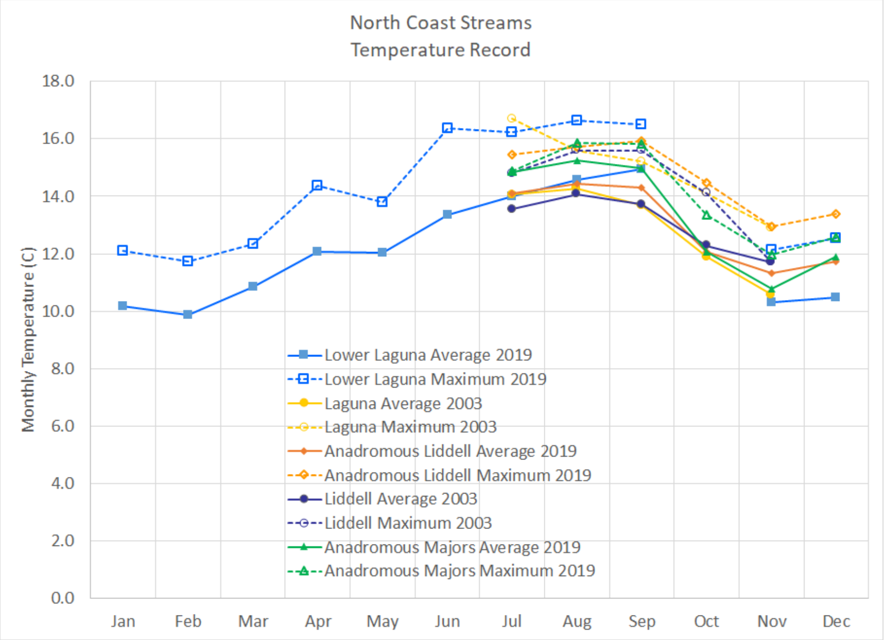
[13] Temperature record at City of Santa Cruz anadromous gage pressure transducers (2016-2019) and temperature monitors (2003). Average and maximum by month of 15-minute readings (pressure transducer readings) and 30-minute readings (2003 data). These are all available data as of January 2020.

Figure 2-1: Water Temperature in North Coast Creeks



Source: City of Santa Cruz monitoring data

Lagoon Habitat

Liddell Creek does not have a fully functional lagoon because the area where a lagoon would form, behind the beach, is occupied by fill from the railway/Highway 1 causeway. The creek enters the beach via a 5-foot by 8-foot culvert bored beneath Highway 1 and through the cliff bordering the northern edge of the creek. The creek valley was filled at this location in the early part of the 20th century, forming a causeway to support rail lines and the present-day Highway 1 corridor. The causeway intersects the creek valley immediately behind the beach and appears to have completely obliterated any former lagoon habitat although there is no known documentation of pre-development conditions. The berm and associated tunnel have significantly altered the form and dynamic function of the Liddell Creek mouth/lagoon.

There is a small pocket beach formed at the mouth (approximately 500 feet wide in shore parallel direction) bounded by rocky headlands composed of Santa Cruz mudstone, a relatively resistant fine-grained sedimentary rock (Phil Williams & Associates (PWA) 2004). Opening of the

Liddell Creek mouth is dependent on storm runoff events to breach the sandbar and sustain the opening. During high flows, the Creek outlet may run straight out from the tunnel mouth into the ocean. At other times there may be a shallow channel to the south along the back beach or the foot of the railroad causeway. Under lower flow conditions the creek flow percolated completely into the beach sand without reaching the sea. Although trace amounts of water may pond behind the beach berm, a dry season lagoon of any substantial size or depth does not form at Liddell Creek.

2.4.2.2 Habitat Conditions Laguna Creek

Laguna Creek supports steelhead and resident rainbow trout populations and may support coho. At the time that the Coho Recovery Plan (NMFS 2012) was produced, Laguna Creek was determined to lack suitable habitat for coho. However, subsequent to that time, a few juvenile coho have been observed in annual snorkel surveys in 2015 (5 YOY), 2016 (2 age 1+), and 2020. For the purposes of the HCP, Laguna Creek is considered potential coho habitat and is managed accordingly.

Watershed/hydrology

Laguna Creek is a second order stream that flows into the Pacific Ocean along the North Coast area of Santa Cruz County. The two major tributaries to Laguna Creek are Reggiardo Creek and Y Creek. The Reggiardo Creek confluence is approximately 4.2 miles upstream of the mouth of Laguna Creek, while the Y Creek confluence is approximately 1.4 miles upstream of the mouth. Laguna Creek drains in a southwest direction off of Ben Lomond Mountain. The watershed area is approximately 7.8 square miles. The elevation of the watershed ranges from sea level at the mouth to approximately 2,420 feet at its headwaters near Empire Grade Road. The approximate stream channel length from the mouth of Laguna Creek to its headwaters is 8.5 miles. The City diversion on Laguna Creek has a capacity of approximately 6.3 cfs and is directly upstream (0.1 miles) of the Reggiardo Creek confluence. The channel gradient from the diversion to the mouth is about 3 percent, and the channel gradient upstream of the diversion to the headwaters is approximately 6 percent (ENTRIX, Inc. 2004b).

There are at least seven known non-City operated diversions on the Laguna-Reggiardo Creek system (ENTRIX, Inc. 2004b) (See Figure 1-3: Laguna Watershed Map). The Sand Hill Bluff site (Diversion #3) diverts through a 10-inch diameter pipe and probably represents the most significant non-City diversion in the Laguna Creek watershed and is directly upstream of the limit of anadromy. Downstream of the Sand Hill Bluff Diversion are the Mills and former Coast Dairies and Land Co. (CDL) diversions (Diversions #1 and 2) (ENTRIX, Inc. 2004b). The CDL diversion may not be operating currently. CDL also historically operated an alluvial well along the lower reach of Laguna Creek that may influence surface flows when operating. This may not be a complete accounting of non- City operated diversions on Laguna Creek and its tributaries. Production numbers and seasons of diversion for the non-City diversions are unavailable and their impacts on Laguna Creek hydrology are unknown though they may divert in excess of 1 cfs (ENTRIX, Inc. 2004b). This level of water diversion can substantially reduce available flow for anadromous salmonids, particularly during the dry season. The City does not have definitive documentation on the legal status of the water rights for these diversions and they are not well documented in State Water Resources Control Board (SWRCB) databases. However, a SWRCB investigation in 2015 determined that the Sand Hill Bluff Diversion was being operated in an unauthorized manner at the time (Kathy Bare - SWRCB, personal communication to Chris Berry, 2015). In addition, the City has both appropriative water rights seniority and control over all downstream riparian rights downstream of its diversions on the north coast streams.

The channel from the Laguna Creek mouth to about 1.43 miles upstream is low gradient (≈ 1 percent) and moderately confined. At this point (near Y Creek confluence), a series of boulder cascades form a complete barrier to anadromous fish passage (Hagar et al. 2017a; also, see following section). In this reach, substrate is a mixture of sand, gravel, and cobbles, and aquatic instream cover is abundant and diverse. Above mile 1.43 to the City diversion, the channel gradient steepens to about 3.4 percent and the valley walls become more confined. The majority of the channel between the anadromous reach and the diversion is mixed bedrock and boulders with patches of sand and gravel deposits. The amount and level of complexity for aquatic instream cover decreases above mile 1.43 (ENTRIX, Inc. 2004b). See Appendix 2: *North Coast Passage Synthesis*.

Reggiardo Creek is a first order tributary to Laguna Creek. The City operates an instream water diversion structure along Reggiardo Creek directly upstream of its confluence with Laguna Creek. The elevation range of Reggiardo Creek watershed is 590 feet above mean sea level (msl) at its confluence with Laguna to 1800 feet msl near its headwaters. The channel length from Reggiardo's confluence with Laguna to its headwaters at Reggiardo Spring is 1.7 miles with a gradient of approximately 9 percent (ENTRIX, Inc. 2004b).

A significant portion of the Laguna Creek watershed is limestone and marble outcroppings, commonly referred to as karst topography. The karst topography has a significant influence on streamflow and summer baseflow by producing multiple springs within the watershed. The karst topography is also more resistant to erosion than other material in nearby watersheds, which results in reduced fine sediment loads. The Laguna watershed also has granitic formations that provide a good source of gravel and cobble. This is evident in the reaches downstream of the City's diversion where large cobble and gravel dominate the streambed substrate (ENTRIX, Inc.

2004b).

The 7.8 square mile watershed is home to slightly over 1,000 people, all on septic service (2ndNature 2006). In a study of Santa Cruz County lagoons, including Scott Creek, San Lorenzo, Aptos, and Soquel, the seasonal loading of nutrients (measured as dissolved inorganic nitrogen or DIN) to Laguna Lagoon was found to be low in comparison to the other lagoons. Surface water DIN and soluble reactive phosphorous (SRP) values measured in the Laguna Creek Lagoon are consistently low, < 5uM and < 2uM respectively (2ndNature 2006).

Instream Habitat

Migration Barriers

The upstream limit of anadromy in Laguna Creek has been identified as a reach beginning near the Y Creek confluence about 1.43 miles upstream of the mouth where the stream gradient increases sharply and the channel is obstructed by large boulders. Observations were made at this site on May 24, 2017 by a team of biologists and engineers from CDFW, NOAA Fisheries, City of Santa Cruz, and Hagar Environmental Science (Hagar et al. 2017a). The team concluded that there may be some flows where adult steelhead could ascend the boulder fall but that the frequency of such events would be insufficient to support an anadromous population upstream (Hagar et al. 2017a).

Entry of steelhead and coho into Laguna Creek is regulated by opening of the mouth, generally under the combined influence of winter tidal and swell conditions and increased inflow resulting from winter storms. Historical alteration of the lower part of the creek and lagoon has created conditions that likely influence lagoon opening and closure. First, the creek valley at the upper end of the lagoon was filled for construction of a railroad in the early 1900s (2ndNature 2006). The creek was rerouted through a tunnel in the bluff at the north edge of the valley. Second, the morphology of the lagoon area was modified in the early 1900s to accommodate agricultural cultivation in the historic marsh area. There are also remnants of a concrete dam located approximately 150 feet downstream of the railroad tunnel. The dam is presently in disrepair and the stream passes unimpaired around the southern end of the structure; however, this dam may have interfered with fish migration in the past.

Observations beginning in 2004 and monitoring instrumentation in place since then indicate that it takes very little increased inflow to open the Laguna Creek Lagoon in the fall and that it generally opens in the mid-October to mid-November time period (2ndNature 2006 and subsequent annual reports for City of Santa Cruz).

Once upstream of the lagoon, migration of adult salmonids is limited only by a few low-flow obstacles, including the concrete apron at the upstream end of the Highway 1 culvert and a few shallow riffle cross-sections. Reduction of flows at these locations during the spawning season, such as through the City diversion or other diversions, can limit the periods when migrating salmonids can pass (HES 2014b). This would apply both to upstream migrating adults and downstream migrating adults and smolts. Analysis of flows needed for passage at these locations was used to set bypass flow requirements under the HCP (HES 2014b, Appendix 3: *Flow Studies*).

Spawning Habitat

The karst topography found in Laguna Creek watershed is considered a fair source for spawning gravel. Granitics are also present in the watershed (ENTRIX, Inc. 2004a). These geological conditions are frequently associated with stable summer/fall base flows and relatively clean streambed gravels and small cobbles. Surveys conducted by ENTRIX, Inc. in 2003 noted that suitable spawning substrate was not extensive and was concentrated within the lower 0.75 miles of stream (ENTRIX, Inc. 2004a). During a spawning flow assessment in the winter of 2006-2007, HES located four study sites in potential spawning habitat in the anadromous reach (HES 2014b). Substrate at these sites was rated as moderately to highly suitable based on the Bovee system (Table 2-1). Substrate suitable for spawning at these sites consisted primarily of sand/gravel mixtures or gravel/cobble mixtures with high proportions of gravel. Lower suitability ratings were generally the result of excessive sand. Cobble rarely made up more than 30% of the substrate at these locations and gravel was generally at 70% to 90% (HES 2014b).

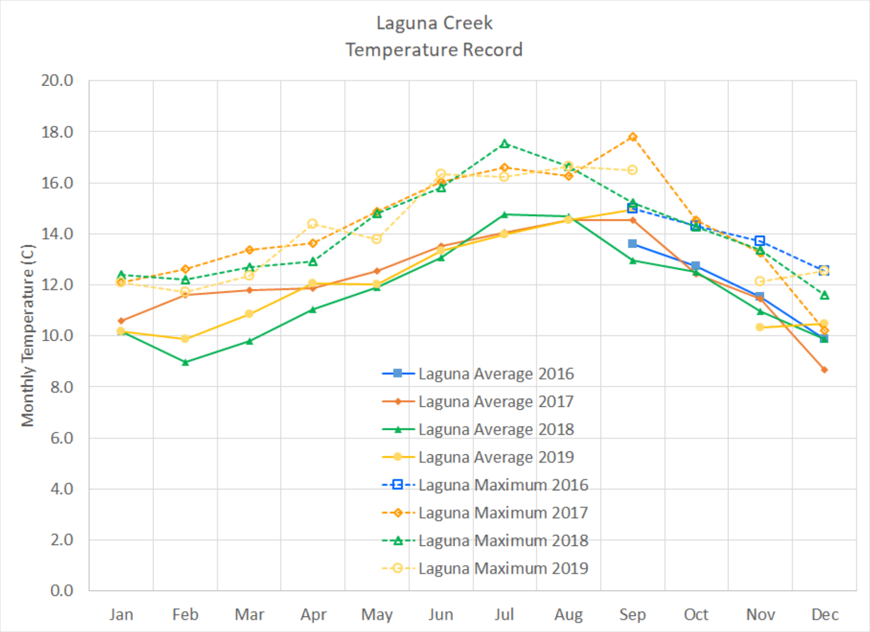
Suitability of habitat for salmonid spawning is partially dependent on flow and, as such, can be altered by the City diversion. A spawning flow assessment to define the relationship between flows and spawning habitat quality for steelhead and coho was conducted in 2006-2007 using the Physical Habitat Simulation (PHABSIM) model (HES 2014b, Appendix 3: *Flow Studies*).

The suitability of habitat for steelhead spawning increases rapidly as flow increases from about 2 cfs and peaks at a flow of 14 to 16 cfs (HES 2014b). Flows of 11 and 22 cfs provide 80% of the peak suitability index value for steelhead. The spawning suitability index for coho rises rapidly from a value of 0 at about 2 cfs to a peak at about 9 cfs. Flows of 7 and 16 cfs provide 80% of peak suitability index value for coho. A flow of 12 cfs in Laguna Creek provides 96% of the peak steelhead suitability index and 94% of the peak coho suitability index. Flows higher or lower than these levels result in increased frequency of depth, velocity, and substrate conditions that are outside the suitable range as defined by habitat suitability criteria used for steelhead and coho spawning (HES 2014b).

Rearing Habitat

Habitat surveys have revealed that rearing habitat in Laguna Creek is dominated by pools and that riffles were quite small and unlikely to be highly productive of aquatic invertebrates (ENTRIX, Inc. 2004a). Fifty-seven percent of the anadromous reach was pool habitat and only 9% was riffle during these surveys. Mean depth of pools averaged only 0.9 feet and maximum depths averaged 1.8 feet. Instream cover was complex and undercut banks were extensive in the lower anadromous reach while boulders, bedrock, and woody debris were important cover objects in the upper part of the creek. Canopy coverage was relatively dense, averaging 75% in the ENTRIX, Inc. survey. This level of canopy is good for salmonids as it allows sufficient light for aquatic plants and invertebrate production while maintaining good shade for cooler temperatures. Temperature monitoring data collected by the City indicates good water temperature conditions for rearing salmonids[14] (Figure 2-1 and Figure 2-2). Monthly average water temperature readings recorded from 2016 through 2019 peaked between July and September at 14°C to 15°C with monthly maximums peaking at 16°C to 18°C (Figure 2-2).

Figure 2-2: Water Temperature in Laguna Creek



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[14] See Section 2.4.2.1 and HES 2014b for discussion of temperature tolerance for steelhead and coho.

Rearing habitat quality varies with flow and is potentially influenced by the City's diversion. During the winter of 2006-2007, the City conducted an assessment of the relationship between flow and rearing habitat quality using PHABSIM (HES 2014b, Appendix 3: *Flow Studies*). The habitat quality index for steelhead rearing in Laguna Creek increases gradually as flow increases from minimum levels and continues to increase, though at lower rates, through the range of simulated flows (HES 2014b). A flow of 5.5 cfs provides 80% of the habitat suitability for steelhead as that provided at a flow of 14 cfs. The rearing suitability index for coho is relatively insensitive to flow across the range of simulated flows. Habitat suitability at the lowest simulated flow of 0.1 cfs is 80% of the peak suitability for coho occurring from 2.25 and 3.75 cfs (HES 2014b). This is the result of the tendency of rearing juvenile coho to use relatively low velocity habitat (Hampton 1988, Hampton 1997, Bovee 1978, Hardy et al. 2001). A flow of 5.5 cfs provides 80% of peak rearing suitability for steelhead and 95% of peak suitability for coho (HES 2014b). See Appendix 3: *Flow Studies*.

Lagoon Habitat

General Lagoon Dynamics

Lagoon habitat has been shown to be very important for rearing juvenile steelhead. Smith (1990) estimated that relatively large numbers of juvenile steelhead were present in San Gregorio, Pescadero, and Waddell lagoons during 1986 in comparison to the numbers of steelhead rearing in upstream areas, particularly larger individuals; that juvenile steelhead that rear in the lagoon experience higher growth rates than stream-reared fish; and that lagoon reared fish comprise a high percentage of returning adult steelhead. Similarly, Bond (2006) found both high growth rates and high rates of return for estuary reared steelhead in Scott Creek. Bond calculated that estuary-reared steelhead comprised between 8% and 48% of all downstream migrating juveniles but 85% of the returning adult population.

While coho may use lagoon habitat, they have not been documented as often in Central California lagoons. When coho have been found in lagoons, it is often during the late spring when they would be migrating to sea as smolts. During monthly sampling of the Navarro River Estuary in 1996 and 1997, out-migrant coho smolts were captured in May, June, and July but coho were not observed at other times (Cannata 1998). All but two coho smolts were captured from the lower estuary sampling sites, suggesting that coho smolts may pass through the freshwater portions of the estuary rather quickly, but hold in the brackish water of the lower estuary for relatively short periods of time (Cannata 1998). Within the Plan Area, in sampling from 2004 through 2019, coho YOY and smolts have been found in Laguna Creek Lagoon only during 2005. They were relatively numerous in May while the mouth was open, declined in the July sample, and all but disappeared by September (2ndNature 2006). There is some thought that Central Coast lagoons may be too warm for coho (Brian Spence, NMFS, personal communication to Jeff Hagar, November 2006).

Central coast lagoons are dynamic and variable environments that cycle between closed freshwater systems and open estuaries. For lagoons in the HCP planning area, streamflow is the dominant factor opening and maintaining a lagoon outlet. Onshore sediment delivery by wave action is the dominant factor closing off the lagoon outlet and temporarily halting streamflow to the ocean (PWA 2004). Under conditions of sufficient inflow, the lagoons operate under a "fill and spill" cycle. Streamflow fills the lagoon until its water surface elevation spills over the crest of the barrier beach. Water flowing over the barrier beach quickly erodes the unconsolidated sand, down-cutting and widening the outlet, thereby releasing even larger amounts of water. Once underway, this erosional process is irreversible until outflow from the lagoon subsides (ENTRIX, Inc. 2004a). Ocean conditions also influence this process through erosion of the beach under high swell conditions or seasonal building of the beach through on-shore delivery of sand (PWA 2004).

Detailed documentation of the timing and duration of sandbar closure for lagoons in Santa Cruz County, including the San Lorenzo River Lagoon, has been provided by the Comparative Lagoon Ecological Assessment Project (CLEAP) and 2ndNature (2ndNature 2006, 2008, 2009a, 2009b, 2009c, 2010a, 2010b, 2011, 2012, 2013, 2014, 2015, 2016). These studies also support the conclusion that the timing of the initial sandbar formation may be driven by sand delivery dynamics during large summer south swells coupled with a spring tidal cycle. Lagoon inflow also has an influence on the timing and persistence of closed lagoon conditions. Regardless of the timing of the sand bar formation, the duration of closure is variable across the lagoons and assumed to be partially dependent upon the water storage capacity of each respective lagoon, as described above. If the water surface elevation of the lagoon reaches the elevation of the sandbar, the bar will erode and eventually breach. In less laterally confined lagoons (little to no active flood control), the water impounded behind the bar can expand horizontally into connected marsh and lateral storage areas, thus reducing the rate at which the elevation of the water behind the bar increases as fresh water is impounded. In general, the less flood-controlled lagoons close earlier and stay closed longer than those located in urban areas where flood control is a priority (2ndNature 2006).

The available data indicate that the circulation regime of coastal lagoons plays a large role in the water quality of the lagoon. When the sandbar is open, marine water mixes with freshwater in an estuarine environment. The lagoon is tidally influenced and possesses a well-mixed water column and relatively uniform vertical profile structure of temperature, dissolved oxygen (DO), pH, and salinity (2ndNature 2006). Depending on river inflows during open lagoon conditions, there may be some salinity stratification with relatively fresh water near the surface and increasing salinity with depth. Under these conditions the temperature is relatively cool with some diurnal warming in the surface layers and relatively high levels of DO throughout the water column (HES 2017). Within days of the sandbar closure, a halocline develops with denser marine water at the bottom overlain by freshwater delivered to the lagoon from the surrounding watershed. The density difference between the surface freshwater layer and the deep saline layer effectively isolates the two layers and prevents mixing of chemical constituents, most notably DO, between the layers.

Habitat conditions for juvenile salmonid rearing are influenced by three main water quality parameters: temperature, salinity, and DO. Lagoons tend to be warmer than upstream flowing reaches due to less influence of shading riparian vegetation. Lagoons also tend to be rich in nutrients and high levels of primary production supporting abundant food resources combined with higher temperatures can support rapid growth rates for rearing salmonids, provided that temperature is not too extreme.[15]

Juvenile steelhead appear to tolerate a range of salinity conditions. Certainly freshwater (~0-4 parts per thousand (ppt) salinity) would be considered highly suitable. Tolerance of full-strength seawater is likely limited, particularly for more juvenile fish, and may have seasonal components. Healthy and vigorous juvenile steelhead have been captured in the fall in the Carmel River Lagoon at salinities of 12-14 ppt and higher (HES 2002; HES 2003a). In the San Lorenzo River Lagoon during 2002, salinity was 4 ppt at the surface but increased to 30 ppt at 2 feet of depth at sites where juvenile steelhead were captured upstream of Riverside Drive in November (H.T. Harvey and Associates 2003b). In July 2004, juvenile steelhead were captured at three sites in the lower San Lorenzo River Lagoon with surface salinities (measured at 0.01 meter (m) depth) ranging from 0.02 ppt to 7.3 ppt, however, salinity at a depth of 0.25 meters (about 10 inches) at these stations ranged from 14.4 to 17.2 ppt (HES 2005b, CLEAP data). Juvenile steelhead are often present in higher salinity water at the mouth of the San Lorenzo River when the mouth is open. Association of juvenile steelhead with higher salinity water is not unique to these lagoons south of San Francisco Bay. In the Navarro River Estuary in 1996 and 1997, steelhead were captured year-round at most sampling sites (Cannata 1998). They were usually most abundant in samples collected from the lower estuary sites before the mouth closed and the lagoon formed (mouth closed September 20 in 1996 and September 5 in 1997) and increased in abundance in the middle and upper estuary sites after the lagoon formed. Steelhead larger than 110 millimeters (mm) fork length (FL) were almost exclusively captured from the lower sampling sites where water temperatures were cooler and salinities were higher than middle and upper estuary sites (Cannata 1998). Steelhead growth rates in the Navarro River

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[15] See section 2.4.2.1 and HES 2014b for discussion of temperature tolerance for steelhead and coho.

Lagoon were lowest during the period the lagoon was closing but accelerated after a period of time. All of these observations would suggest that juvenile steelhead can tolerate relatively high salinity in lagoon habitats. Other factors, such as food abundance and levels of other parameters including temperature and DO, may also influence salinity tolerance.

Optimal DO levels for steelhead are 7 milligrams (mg) per liter (l) and above, although levels down to about 5 mg/l can be tolerated (US EPA 1976, US EPA 1986, Raleigh et al. 1984). Suitability falls off rapidly at levels below 5 mg/l and the incipient lethal level is approximately 3 mg/l or less, depending on environmental conditions, especially temperature (Raleigh et al. 1984).

The transition from a well-mixed, tidally influenced system under open lagoon conditions to a closed lagoon results in transitional water quality dynamics that influence habitat conditions for salmonids. Cessation of tidal inflows of cold, well-oxygenated marine water results in warming of lagoon waters, particularly in the San Lorenzo River Lagoon where air temperature is generally warmer. After lagoon closure there is usually a layer of marine water trapped in the deeper parts of the lagoon. The density difference between the surface freshwater layer and the deep saline layer effectively isolates the two layers and prevents mixing of chemical constituents, most notably DO, between the layers. DO is consumed by processes of decay in the saline water and is not replenished. This layer also becomes much warmer than the overlying freshwater. As a result, a layer of saline, warm, and de-oxygenated water forms at depth, which is not habitable by steelhead, forcing them into the surface freshwater layer. The saline water is gradually flushed out with timing dependent on the amount of freshwater inflows. The process can take up to two to four weeks and in the San Lorenzo River Lagoon a shallow saline lens may persist even longer.

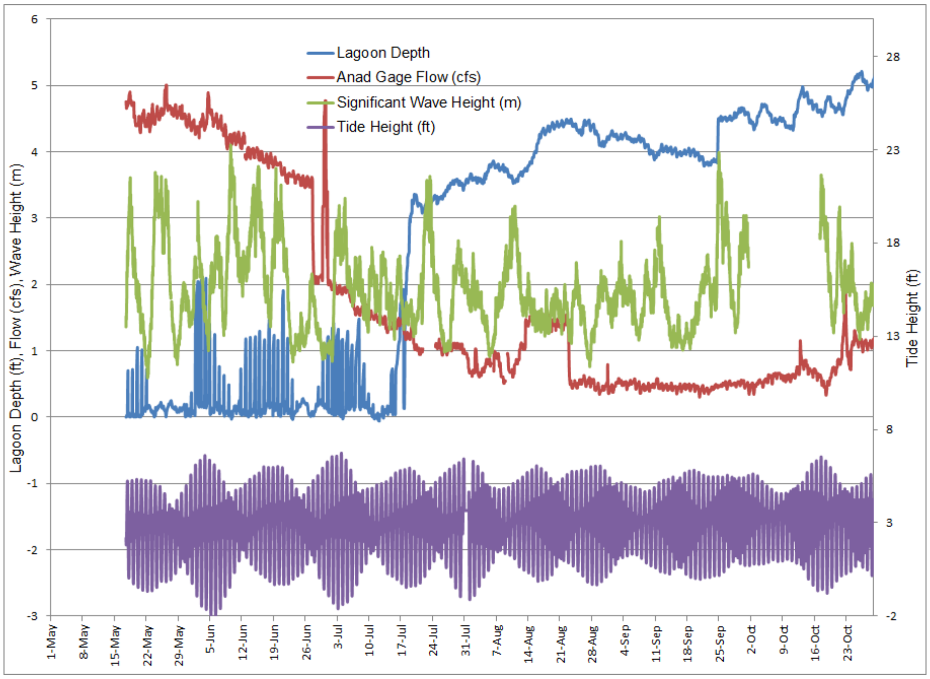
Laguna Creek Lagoon

Laguna Creek Lagoon provides rearing habitat for steelhead and possibly for coho. As previously described, the morphology of the upper part of the lagoon has been significantly altered by construction of the railroad and Highway 1. The natural channel of Laguna Creek was filled in the early 1900s to create a bed for the rail line and highway. The fill is approximately 150 feet wide and crests about 80 feet above the lagoon (2ndNature 2006). Laguna Creek was rerouted through a tunnel dug into bedrock cliff at the northern edge of the valley. At some time after the creek channel was filled and rerouted, higher parts of the marsh to the west of the fill were used for agriculture. These areas were abandoned and have largely reverted to marsh vegetation (2ndNature 2006). A small dam was built on the creek just west of the fill, presumably for an agricultural diversion. At present, the stream has eroded the bank at the southern edge of the dam and now flows around the remnants of the structure. Laguna lagoon consists of a narrow, relatively deep channel that runs along the base of the northern cliffs and then through the marsh, ultimately crossing to the base of the southern cliff. There is an extensive shallow pond in the marsh to the south of the lagoon channel that is connected to the main lagoon when the lagoon is at its highest stages and drains back into the lagoon through an artificial drainage ditch. The shallow pond does not provide habitat for rearing salmonids. In 2007, the City began bypassing a minimum of 0.25 cfs at the Laguna Creek Diversion and more recently the City has been bypassing interim flows that are similar to the proposed HCP Conservation Flows.

Sandbar Formation

Lagoon formation at Laguna Creek is dynamic and variable from year to year, although there is a general pattern of dry season closure (Table 2-2). Since regular observations began in 2004, the mouth of Laguna Creek has generally closed initially between late-April or May and early July. It generally remained closed until the fall or early winter (Figure 2-3). A typical seasonal pattern for Laguna Lagoon is depicted in Figure 2-3. An initial oscillating pattern of lagoon stage tracks tidal stage. As streamflows diminish, closure of the mouth is indicated by a rapid sustained increase in lagoon stage. In some years there has been a period of time when the mouth opens and closes intermittently, particularly in years with higher inflow in the spring and early summer, such as 2016 (Figure 2-4). The sequential closing and breaching in May, June and July show this pattern, with the lagoon volume quickly climbing to over 20 ac-ft before the lagoon reaches capacity and breaches. This pattern also occurred in 2005. Higher inflows may contribute by filling the lagoon to its capacity (approximately 20-25 ac-ft.) and providing enough stream power to erode the sandbar at the mouth, draining the lagoon. However, it is likely other factors, possibly a lower sandbar crest elevation, were in play as higher inflows have occurred in other years without such an extended breaching period (Table 2-2). The mouth has generally opened again between mid-October and early December, although intermittent closure and re-opening occurred through January in the winter of 2008-2009, a winter of low rainfall during the early winter. During the period when observations have been made, opening of the mouth in the fall has sometimes been associated with increased runoff from early storms (*e.g.* 2011) and sometimes not (*e.g.* 2016).

Figure 2-3: Laguna Lagoon Stage, Streamflow, Wave Height, and Tides 2012



Source: lagoon stage from 2ND Nature, streamflow from Balance Hydrologics, wave and tide data from NOAA**.**

Table 2-2: Lagoon Inflows and Summer Sandbar Closure and Opening Dates for Laguna Lagoon

	Water Year precipitation (in)[1]	August Average daily inflow to Lagoon (cfs)[2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)	Number of days microtidal May 15 to Oct. 31 (168 days in period)[3]	Mean of daily average water depth at YSI site (June-Aug)
2004	35.49	0.03	14-May	15-May	154	0 0%	0.91
2005	64.83	0.34	10-May	6-July	112	3 2%	2.45
2006*	67.78	1.17	N/A	N/A	N/A	N/A	N/A
2007	25.4	0.38	Before 15-May	Before 15-May[4]	168	N/A	3.93
2008	39.6	0.25	Before 15-May	Before 15-May[4]	168	N/A	3.68
2009	36.52	0.18	21-May	21-May	157	4 2.5%	2.57
2010	48.88	0.70	Mid-May	Estimate at 5-Aug	138	7 4%	3.01
2011	62.15	1.58	9-June	29-Jul	83	60 36%	2.66
2012	34.35	0.75	18-Jul	18-Jul	106	17 10%	2.01
2013	36.2	0.91	Before 15-May	Before 15-May	168	N/A	4.69
2014	24.5	0.26	Before 15-May	Before 15-May	168	N/A	3.21
2015	35.5	0.34	1-June	1-June	152	N/A	4.37
2016	48.6	2.01	15-Aug	15-Aug	100	0	2.96

Source: 2NDNATURE

N/A not available, no monitoring performed, or limited data

*2006 Monitoring did not begin until August 22nd, 2006.

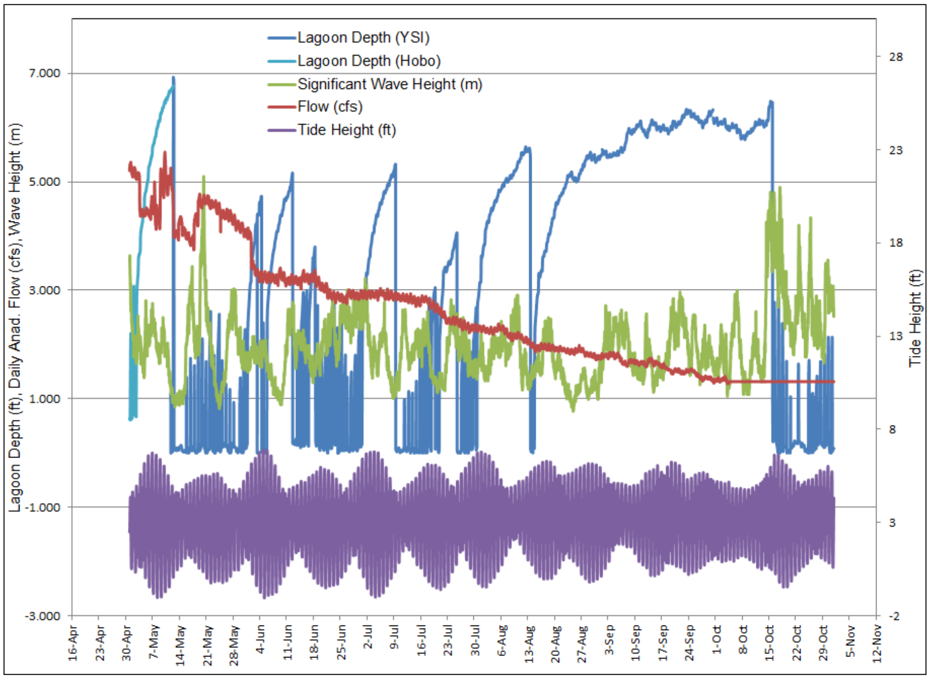
[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from US Geological Survey (USGS) gage #11161000, San Lorenzo River at Santa Cruz, average Q integrated over one day.

[3] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[4] Already closed when monitoring initiated on May 15.

Figure 2-4: Laguna Creek Lagoon Stage, Streamflow, Wave Height, and Tides 2016, Preliminary Data



Source: lagoon depth from 2ND Nature and City of Santa Cruz, streamflow from Balance Hydrologics, wave and tide data from NOAA.

Lagoon Circulation Regime and Water Quality

Laguna Creek Lagoon generally provides habitat with good conditions for rearing juvenile steelhead over the dry season. The greatest determinants of habitat quality are the degree to which the lagoon is closed and the amount of freshwater inflow. When the lagoon is closed it provides good rearing habitat and supports good growth rates for juvenile steelhead. An open lagoon can provide good rearing habitat when the sandbar elevation at the mouth is relatively high and depth is maintained in the lagoon. Alternatively, when the mouth is open and the sandbar elevation is low, the lagoon drains and there is little suitable rearing habitat. Freshwater inflows influence the lagoon stage, the speed of transition to freshwater habitat, and may influence the timing and duration of lagoon closure.

During the period of summer lagoon closure, the lagoon stage remains relatively high as long as there is sufficient inflow from Laguna Creek (Table 2-2). The highest summer lagoon stages have occurred since 2007 when the City began bypassing approximately 0.25 cfs at the Laguna-Reggiardo Diversion and later as the City began interim implementation of HCP proposed bypass flows. The lowest summer lagoon stages occurred in 2004 when inflow to the lagoon was extremely low.

During closed lagoon conditions, the Laguna lagoon transitions rather quickly to a freshwater system with little or no saline lens even in the deeper parts of the lagoon (Table 2-3). This condition is disrupted when high tide and swell result in waves washing over the sandbar or the lagoon breaches. For example, there were five such events between June and November 2005 (2ndNature 2006). These events are associated with salinity increases to between 10 and 20 ppt at the bottom of the lagoon and small increases in salinity (less than 2ppt) in surface waters. One event in September 2005 was sufficiently large to result in salinity increase to 15 ppt at the surface. Salinity gradually returned to near zero within one to two weeks for the smaller events but took three to four weeks for the larger event in 2005. Steelhead abundance was high during monthly surveys in September and November of 2005 (2ndNature 2006), indicating that higher salinity alone is not a problem for rearing steelhead.

Water temperature in Laguna lagoon is generally at levels providing good conditions for steelhead with abundant food resources[16] (Table 2-4). The CLEAP study found that a balanced mix of amphipods and isopods were the most common invertebrates in the Laguna invertebrate community, and that the lagoon had consistently moderate to high diversity and abundance values for the invertebrate community (including potential fish food) relative to other lagoons (2ndNature 2006). The warmest temperatures occur in July and August.

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[16] See Section 2.4.2.1 and HES 2014b for discussion of temperature tolerance for steelhead and coho.

Table 2-3: Salinity Conditions from Continuous Monitoring Record in the Laguna Creek Lagoon in Comparison to Freshwater Inflow and timing and Duration of Sandbar Closure

	Water Year precipitation (in)[1]	August Average daily inflow to Lagoon (cfs)[2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)	Number of days microtidal May 15 to Oct. 31 (168 days in period)[3]	% of observations of surface salinity > 5 ppt (June-Aug)	% of observations of bottom salinity > 5 ppt (June-Aug)
2004	35.49	0.03	14-May	15-May	154	14 (8%)	N/A	7%
2005	64.83	0.34	10-May	6-July	112	21 (12.5%)	0%	43%
2006*	67.78	1.17	N/A	N/A	N/A	N/A	N/A	N/A
2007	25.4	0.38	Before 15-May	Before 15-May[4]	168	0	1%	0%
2008	39.6	0.25	Before 15-May	Before 15-May[4]	168	0	0%	39%
2009	36.52	0.18	21-May	21-May	157	4 2.5%	19%	25%
2010	48.88	0.70	Mid-May	Estimate at 5-Aug	138	7 4%	18%	86%
2011	62.15	1.58	9-June	29-Jul	83	60 36%	14%	40%
2012	34.35	0.75	18-Jul	18-Jul	106	17 10%	0%	22%
2013	36.2	0.91	Before 15-May	Before 15-May	168	0	0%	6%
2014	24.5	0.26	Before 15-May	Before 15-May	168	0	9%	0%
2015	35.5	0.34	1-June	1-June	152		30%	24%
2016	48.6	2.01	15-Aug	15-Aug	100	0	30%	65%

Source: 2NDNATURE

N/A not available, no monitoring performed, or limited data

*2006 Monitoring did not begin until August 22nd, 2006.

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz, average Q integrated over one day.

[3] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[4] Already closed when monitoring initiated on May 15.

Table 2-4: Temperature Conditions from Continuous Monitoring Record in the Laguna Creek Lagoon in Comparison to Freshwater Inflow and Timing and Duration of Sandbar Closure

	Water Year precipitation (in)[1]	August Average daily inflow to Lagoon (cfs)[2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)	Number of days microtidal May 15 to Oct. 31 (168 days in period)[3]	Average of Daily Maximum Air Temperature (°C)[3]	Maximum Weekly average Temperature (MWAT)	Number of Days with Average Surface Temperature Exceeding 19°C. (June-Aug)	Number of Days with Average Surface Temperature Exceeding 21°C. (June-Aug)	Number of Days with Daily Maximum Surface Temperature Exceeding 25°C. (June-Aug)
2004	35.49	0.03	14-May	15-May	154	14 (8%)	21.5	N/A	N/A	N/A	N/A
2005	64.83	0.34	6-Jul	6-July	112	21 (12.5%)	20.8	N/A	N/A	N/A	N/A
2006*	67.78	1.17	N/A	N/A	N/A	N/A	21.8	N/A	N/A	N/A	N/A
2007	25.4	0.38	Before 15-May	Before 15-May[4]	168	0	22.2	20.7	59(66%)	5(6%)	0
2008	39.6	0.25	Before 15-May	Before 15-May[4]	168	0	22.0	20.5	50(54%)	0	0
2009	36.52	0.18	20-May	21-May	157	4 (2.5%)	21.7	20.9	57(62%)	8(9%)	0
2010	48.88	0.70	Estimate 5-Aug	Estimate 5-Aug	138	7 (4%)	20.6	18.0	1(1%)	0	0
2011	62.15	1.58	29-Jul	29-Jul	83	60 (36%)	19.9	19.2	6(8%)	2(3%)	4
2012	34.35	0.75	18-Jul	18-Jul	106	17 (10%)	21.1	18.3	1(1%)	0	0
2013	36.2	0.91	Before 15-May	Before 15-May	168	0	21.7	20.4	40(43%)	0	0
2014	24.5	0.26	Before 15-May	Before 15-May	168	0	21.3	21.7	66(72%)	19(21%)	0
2015	35.5	0.34	1-June	1-June	152	N/A	23.6	21.1	78(85%)	11(12%)	0
2016	48.6	2.01	15-Aug	15-Aug	100	0	20.9	16.8	0	0	0

Source: 2NDNATURE

N/A not available, no monitoring performed, or limited data

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz, average Q integrated over one day.

[3] Air temperature data provided by the California Irrigation Management Information System (CIMIS) website (https://cimis.water.ca.gov/). Data represents an average of two weather stations: DeLaveaga station (#104) is located in Santa Cruz, CA at an elevation of 91.4 MSL and Pajaro station (#129) is located adjacent to the Pajaro River at 65 MSL.

[4] Already closed when monitoring initiated on May 15.

Even though the Laguna lagoon is relatively shallow, there appears to be temperature stratification with cooler water at depth during periods when no saline bottom layer exists. Conversely, when saline bottom water occurs after lagoon closure or after waves wash over the beach, the bottom water can be significantly warmer than the surface water. The most favorable conditions for juvenile salmonids generally occur in the upper part of the water column though conditions can be good to the bottom when the lagoon has no saline layer at the bottom. Daily maximum surface temperatures have ranged from 13.6°C to 28.0°C during the June to August period while daily average temperatures have ranged from 12°C to 22.5°C. The coolest temperatures have occurred during open lagoon conditions with tidal influence. The seven-day MWAT often exceeds 19°C in Laguna lagoon during the June-August period, ranging from 65 days (76%) in 2014 to 3 days (4%) or less in 2011, 2010 and 2012 (Table 2-3). This is a rather conservative criterion and does not account for potentially high food levels in Laguna lagoon that ameliorate the effects of higher temperature. For example, annual City abundance monitoring indicated that steelhead were thriving in the lagoon in 2009, 2014, and 2015 (HES 2010, HES 2015, HES 2016) despite frequent occurrences of MWAT over 19°C (Table 2-4 and Table 2-6). In each year, abundance was high in the fall; catch rates increased between June and September; juvenile steelhead entered the lagoon between June and September; steelhead present in June grew over the summer; and tagging indicated that most fish present in June were still present in September (HES 2010, HES 2015, HES 2016). While daily average temperature frequently exceeds 19°C it exceeds 21°C much less frequently. Lethal temperature has occurred in bottom waters under high salinity conditions but in surface water only briefly in 2011 (Table 2-3).

Continuous monitoring conducted annually in Laguna lagoon demonstrates significant diel and seasonal variation in DO at the surface (for example 2ND Nature 2009b). The available data indicate that there is substantial oxygen demand in Laguna Lagoon and that DO levels may often drop to critical levels for steelhead (Table 2-5). For example, there were a substantial number of days with DO levels declining to less than 5 mg/l at both the surface and bottom in most years (Table 2-5). It is likely that many of the low values result from daily oxygen cycling with nocturnal depletion through the process of respiration, but higher levels during the day generated by photosynthesis. Juvenile steelhead may be able to tolerate this daily cycling.

Table 2-5: Dissolved Oxygen Conditions from Continuous Monitoring Record in the Laguna Creek Lagoon in Comparison to Freshwater Inflow and Timing and Duration of Sandbar Closure

	Water Year precipitation (in)[1]	August Average daily inflow to Lagoon (cfs)[2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)	Number of days microtidal May 15 to Oct. 31 (168 days in period)[3]	Number of days with minimum daily surface DO 5 mg/ l or less (June-Aug)	Number of days with minimum daily bottom DO 5 mg/ l or less (June-Aug).	% of observations of surface DO <=7 mg/l (June-Aug).	% of observations of bottom DO <=7 mg/l (June-Aug).
2004	35.49	0.03	14-May	15-May	154	14 (8%)	N/A	N/A	N/A	N/A
2005	64.83	-0.34	10-May	6-July	112	21 (12.5%)	N/A	61	N/A	32
2006*	67.78	1.17	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2007	25.4	0.38	Before 15-May	Before 15-May[4]	168	0	N/A	N/A	N/A	N/A
2008	39.6	0.25	Before 15-May	Before 15-May[4]	168	0	0	76	63	77
2009	36.52	0.18	20-May	21-May	157	4 (2.5%)	1	74	6	43
2010	48.88	0.70	Estimate at 5-Aug	Estimate at 5-Aug	138	7 (4%)	0	64	29	61
2011	62.15	1.58	29-Jul	29-Jul	83	60 (36%)	42	70	77	48
2012	34.35	0.75	18-Jul	18-Jul	106	17 (10%)	6	31	20	16
2013	36.2	0.91	Before 15-May	Before 15-May	168	0	16	3	75	19
2014	24.5	0.26	Before 15-May	Before 15-May	168	0	2	15	27	25
2015	35.5	0.34	1-June	1-June	152		0	55	80	63
2016	48.6	2.01	15-Aug	15-Aug	100	0	0	23	4	25

Source: 2NDNATURE

N/A not available, no monitoring performed, or limited data

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz, average Q integrated over one day.

[3] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[4] Already closed when monitoring initiated on May 15.

Low DO levels can be a problem during lagoon breaching in the fall/early winter. This was observed both in 2004 and 2005 (2ndNature 2006). This may be due to turbulence during the breach event that mobilizes partially decomposed organic matter. A significant phytoplankton/macroalgae bloom during September and early October 2005 was also associated with increased organic matter loading, increased biological oxygen demand, and sustained low DO, low pH and low ORP values during late September early October (2ndNature 2006).

Lagoon Steelhead Habitat Conditions and Salmonid Abundance Surveys

Abundance of rearing juvenile steelhead has been measured in annual surveys in 2004 and 2005 (2ndNature 2006) and since 2008 (HES 2005a, HES 2009a, HES 2010, HES 2011a, HES 2012, HES 2013, HES 2015, HES 2016, HES 2017, HES 2018, HES 2019 and HES 2020). Coho were captured in June 2005 and largely disappeared from samples by the end of the summer (2ndNature 2006). A few coho were also captured in the lagoon in June 2020 but none were captured in the fall (HES *in draft*). Abundance of juvenile steelhead was estimated as catch per haul before 2011 except 2005 (Table 2-5) and by both catch per haul and by mark-recapture population abundance estimates since 2011 (Table 2-6). In 2005, population estimates of juvenile steelhead in the lagoon (based on recaptures of passive integrated transponder (PIT) tagged fish) ranged from a high of 2,449 in July to a low of 675 by November 2005 (2ndNature 2006). Mark-recapture estimates have not been possible for all surveys due to low abundance after early fall breach (2011) and open lagoon conditions in the spring of 2012 and 2015 and spring and fall of 2019.

Abundance has fluctuated from year to year and with season. Lowest abundances have been observed on a few occasions when the lagoon is open with low sandbar elevation or has recently closed at the time of the survey. It is likely that steelhead migrate between the lagoon and upstream areas during the rearing season and may leave the lagoon for upstream areas when lagoon conditions deteriorate. This is consistent with observations of steelhead migrating between lagoon and upstream areas in nearby Scott Creek (Hayes et al. 2011) and in the San Lorenzo River (HES 2017, 2018). In other years mark-recapture estimates reveal that steelhead were more abundant in the lagoon in the fall than they had been in spring as occurred in 2014, 2016 and 2018 (Table 2-6).

Table 2-6: Steelhead and Coho Catch per Seine Haul in Laguna Creek Lagoon at Consistently Sampled Sites

	Steelhead Catch per Haul				Coho Catch per Haul			
	June	**Jul**	**Sep**	**Oct**	**June**	**Jul**	**Aug**	**Oct**
2004		2.4	0			0	0	
2005	N/A	N/A	N/A	N/A	P		P	
2008	11		6		0		0	
2009	7		19		0		0	
2010	13			1.7	0			0
2011	19.8			0.1	0			0
2012	11.3		10.3		0		0	
2013	28		8.6		0		0	
2014	20		33		0			
2015	0.1			11.4	0			0
2016	1.1		5.2		0		0	
2017	42.8		14.5					
2018	14.3		6.5					
2019	17.0		2.5		0		0	

Source: data from HES 2005, HES 2009, HES 2010, HES 2011a, HES 2012, HES 2013, HES 2014a, HES 2015, and HES 2016, HES 2017, HES 2018, HES 2019, and HES 2020

NA- not available, measured as biomass

P- present, numbers not reported

Table 2-7: Steelhead Population Abundance Estimates in Laguna Creek Lagoon

	Steelhead Population Estimate	
	Spring	**Fall**
2011	300	No estimate
2012	No estimate	370
2013	499	259
2014	256	828
2015	No estimate	267
2016	45	136
2017	641	548
2018	193	242
2019	No estimate	No estimate

Source: data from HES 2012, HES 2013, HES 2014a, HES 2015, HES 2016, HES 2017, HES 2018, HES 2019, and HES 2020.

Growth rates of steelhead in Laguna Lagoon are variable but generally good. Growth rates measured by NMFS in 2005 (estimated from recaptures of PIT tagged fish) were highest early in the summer at ~0.8mm/day (n=6) and were still high by September and November, but had dropped to just over 0.5mm/day (n=52 and 39 respectively). These growth rates were consistent with those observed for steelhead in other Santa Cruz County lagoons in 2005 (2ndNature 2006). The majority of the population in the lagoon reached smolt size (~150mm FL) by November (2ndNature 2006). Growth rates have ranged from 0.43 mm/day to 0.99 mm/day since 2012. In the year with highest growth (2018) the lagoon was open intermittently through mid-July but was moderately deep with a perched outlet. There was a moderate abundance of larger (100mm to 180mm FL) juvenile steelhead present in June but only about a third remained in September (HES 2019). In addition, a large number of smaller juveniles entered the lagoon after June. In the two years with lowest growth rates (2013 and 2014) the lagoon closed before mid-May and remained closed all summer with relatively low inflow but suitable water quality (HES 2014a, HES 2015). Both years had large numbers of relatively large juveniles (150mm FL or greater) present in June. In 2013 abundance decreased over the summer but in 2014 it increased (Table 2-8). Excluding the two years with only one recapture (2012 and 2015), the second highest growth rates were in 2017, another year with open lagoon until mid-July. The sandbar was also relatively high in 2017 with resulting higher lagoon stage. June had the highest abundance of juveniles recorded in all the June surveys plus large numbers of YOY that were too small to tag and not included in the population estimate. Abundance of the larger size class declined substantially by September. Interestingly, one of the June-tagged fish was recorded at the PIT tag antenna at the Felton Diversion on November 17 (HES 2018). This fish would have had to enter the ocean from Laguna Lagoon before mid-July when the mouth closed, and enter the San Lorenzo River Lagoon, which was mostly open between mid-July and November (2ND Nature 2018). This observation suggests the potential disposition of other members of the class.

Table 2-8: Laguna Creek Lagoon Steelhead Tagged in June and Recaptured in September, Annual Averages

	Number Recaptured	Average Growth Rate (mm/day)	Average Growth (mm)	Fall CPUE*	June CPUE*
2012	1	0.86	83	10.3	11.3
2013	10	0.48	47	8.6	28
2014	72	0.43	42	33	20
2015	1	0.99	124	11.4	0.1
2016	0	NA	NA	5.2	1.1
2017	13	0.66	64	14.5	42.8
2018	23	0.99	104	6.5	14.3

* catch per unit effort (CPUE)

Laguna lagoon is capable of supporting relatively large numbers of rearing steelhead over the summer and producing smolt-size fish in a single growing season. Although temperature, DO, and salinity can all be at levels thought to be marginal for steelhead, they appear to grow and survive quite well, likely due to an abundance of high-quality food organisms. Conditions for rearing steelhead appear to be much improved by the interim flow bypasses implemented since 2007.

2.4.2.3 Habitat Conditions Majors Creek

Majors Creek supports populations of steelhead and resident rainbow trout. Majors Creek is not considered potential habitat for coho under current conditions in the Coho Recovery Plan (NMFS 2012). Juvenile coho were observed in Majors Creek during annual snorkel surveys conducted by the City in 2020, the first time since surveys were initiated in 2006 (Berry et al. 2019). Juvenile coho were also observed in Laguna Creek in 2020. Numbers observed in Majors Creek were low relative to juvenile steelhead and this occurrence is considered transient. For the purposes of the HCP, Majors Creek is not considered potential coho habitat.

Watershed/hydrology

Majors Creek is a second order stream that flows into the Pacific Ocean along the North Coast area of Santa Cruz County. The elevation of the watershed ranges from sea level at the mouth to approximately 1800 feet at its headwaters near Felton peak. The watershed area is 5.9 square miles and the approximate stream channel length from the mouth of Majors to its headwaters is 5.9 miles. The City diversion on Majors Creek has a capacity of about 2.1 cfs and is located approximately 2.2 miles upstream from the mouth of Majors Creek. The average channel gradient from the diversion to the mouth is about 3 percent, although there are steeper sections, including a very steep section forming the limit of anadromy about 0.7 miles upstream from the mouth. The channel gradient upstream of the diversion to the headwaters averages approximately 6 percent (ENTRIX, Inc. 2004b). There are numerous small springs and seeps that contribute to Majors Creek downstream of the City’s diversion, but there are no substantial tributaries (ENTRIX, Inc. 2004a).

There are at least four known non-City operated diversions on Majors Creek (ENTRIX, Inc. 2004b). Three diversions, operated by a private diverter, are located in the anadromous reach just upstream of the Highway 1 crossing. These diversions consist of two pumps with 2-inch diameter intake pipes and a subsurface perforated pipe and they likely represent the most significant non-City diversions in the Majors Creek watershed (ENTRIX, Inc. 2004b). There are also diversions upstream of the City diversion (Chris Berry, personal communication to Kindra

Loomis, 2004, cited in ENTRIX, Inc. 2004b). Production numbers and season of diversion for the non-City diversions are unavailable and their impacts on Majors Creek hydrology are unknown. No rigorous effort has been undertaken to identify or quantify all diversions from Majors Creek. This assessment is based on available observations and information and is not necessarily a comprehensive accounting of all non-City diversion facilities (ENTRIX, Inc. 2004b). The City has no definitive documentation on the status of the water rights for these diversions, however it is known that their validity is questionable given the inaccuracies and lack of document in the SWRCB e-WRIMS database and the fact that the City possesses the senior appropriative water right and controls riparian rights downstream of its diversion.

Upstream of the anadromous barrier located about 0.7 miles upstream from the mouth (see following section), the channel has a high gradient, as exemplified by a cascade and step-pool bedform with the dominant substrate alternating between boulder and sand (ENTRIX, Inc. 2004b). The channel has a low width-to-depth ratio, and is well-entrenched (i.e., vertically contained within the valley), with little opportunity for over-bank flows (ENTRIX, Inc. 2004b).

In the anadromous reach, downstream of the boulder cascade section, the channel gradient decreases and the channel becomes less entrenched as the valley walls widen. Large Woody Debris (LWD) and debris jams are found throughout this reach (ENTRIX, Inc. 2002, ENTRIX, Inc. 2004a, HES 2014b). Recruitment of LWD in Majors Creek may be in part due to the presence of late-succession forest (not logged for several decades) upstream of the City's diversion location, as well as the steep banks and canyon walls, which encourage tree falls. The area downstream of the City diversion was logged approximately 100 years ago, or possibly more recently, but appears to have more wood recruitment and/or less removal than other adjacent watersheds (Chris Berry, personal communication to Kindra Loomis, cited in ENTRIX, Inc. 2004b). Much of the LWD in Majors Creek is large diameter redwood and Douglas fir tree trunks that have fallen into the creek. In some locations LWD plays a key role in retarding the downstream movement of excessive fine sediment with deep pockets of sand found upstream of debris jams. LWD was much more prevalent in the non-anadromous reach of the stream than in the anadromous reach (ENTRIX, Inc. 2004b).

The dominance of sand substrate in pools, high embeddedness of riffles, and sand deposition in the lee of boulders and LWD are all indicative of a transport-limited system, where the sediment supply is greater than the capacity of the stream to transport the sediment load (ENTRIX, Inc. 2002). A large portion of the Majors Creek watershed is underlain by the Santa Margarita formation, which is composed of friable, fine to very coarse-grained sandstone (Brabb et al. 1997 cited in ENTRIX, Inc. 2004b). A substantial amount of the watershed upstream of the City's diversion is privately held and was historically logged for timber production. Old logging roads remain in several places in the watershed. These factors likely contribute to high fine sediment loads evident throughout the Majors Creek system (ENTRIX, Inc. 2004b). About 2,000 feet below the City's diversion, Majors Creek begins flowing through a zone dominated by igneous, quartz diorite rock. The quartz diorite is more resistant to erosion relative to other rocks within the North Coast Unit, and leads to a more confined, steep valley wall section with a high gradient (ENTRIX, Inc. 2004b). It may also serve as a good source of gravel, which was evident in the anadromous reach during habitat characterization conducted in 2003 (ENTRIX, Inc. 2004b).

Instream Habitat

Migration Barriers

The upstream limit of anadromy in Majors Creek is a natural migration barrier about 0.7 miles upstream of the mouth formed by a short reach (0.15 mi) of extremely steep (>10 percent gradient) bedrock and boulder cascades (Hagar et al. 2017a). Entry of steelhead to Majors Creek, as for the other north coast streams, is regulated by opening of the mouth, generally under the combined influence of winter tidal and swell conditions and increased inflow resulting from winter storms. The creek enters the back beach area confined between a raised parking area and a small topographic high point at the center of the back beach area (ENTRIX, Inc. 2004a). The available area for lagoon formation is very small and it is likely that early winter flows are sufficient to crest the beach and open the creek mouth. A local landowner reports that the sandbar stays open most of the winter and is breached during the summer by high tides and wave action (Chris Berry, personal communication to Kindra Loomis, 2004 cited in ENTRIX, Inc. 2004a).

Once upstream of the lagoon, migrating adult salmonids face few obstacles to migration in Majors Creek until the boulder fall 0.7 miles upstream. The creek was rerouted through a tunnel in the bluff at the south edge of the valley when the valley was filled for the Highway 1/railroad corridor. There is a shallow cross-section at the upper edge of the tunnel that may impair fish passage at lower flows. There is also a wide, steep riffle, just upstream from one of the lower diversions that also poses an obstacle at lower flows.

Three critical riffle cross-sections were evaluated during the winter of 2006-2007 using the Thompson methodology[17] (HES 2014b). Passage criteria for adult steelhead (a depth of at least 0.6 feet across at least 10% of the cross-section) were met at flows of 10.2 cfs and 12.4 cfs at critical riffles and at a flow of 8.7 cfs at the Highway 1 apron. The most critical riffle section is the furthest upstream, just above the diversion location a few hundred feet upstream of the

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[17] As of 2012 the preferred method of critical riffle analysis (CRA) was updated by CDFW (CDFW 2012). The CDFW CRA has the same theoretical basis as the Thompson method but provides greater detail and clarity on methods.

Highway 1 culvert.

Downstream migration of smolts can also be influenced at the shallow cross-sections evaluated for adult passage. Smolt migration typically occurs in April, May, and possibly into June, but is influenced by stream flow and conditions at the mouth. Using 0.3 feet as a minimum depth criteria for downstream smolt migration and using the same three critical riffle sections as for the adult analysis, smolt passage criteria would be met at flows of 1.8 to 2.9 cfs in Majors Creek (HES 2014b).

Spawning Habitat

As previously described, a large portion of the Majors Creek watershed is underlain by the Santa Margarita formation. In addition, the watershed was formerly logged, and both the underlying watershed material and logging activity contribute to high delivery of fine sediment to the anadromous reach (ENTRIX, Inc. 2004a). Substrate in the anadromous reach is predominantly sand (greater than 50 percent in most habitat units) and gravel with some bedrock, boulders, and large cobble (ENTRIX, Inc. 2004a). Gravels suitable for spawning are distributed sporadically within the anadromous reach and are fair quality (ENTRIX, Inc. 2004a). The primary limiting factor for spawning habitat in the anadromous reach is the limited availability of spawning gravels in the pool tails (ENTRIX, Inc. 2004a).

During a spawning flow assessment in the winter of 2006-2007, HES located four study sites in potential spawning habitat in the anadromous reach of Majors Creek (HES 2014b). Substrate at these sites was rated as moderately to highly suitable based on the Bovee system (Bovee 1978, see also Table 2-1). Substrate suitable for spawning at these sites consisted primarily of sand/gravel mixtures or gravel/cobble mixtures with high proportions of gravel. Lower suitability ratings were generally the result of excessive sand. Cobble rarely made up more than 30% of the substrate at these locations and gravel was generally at 70% to 90%.

Suitability of habitat for salmonid spawning is partially dependent on flow and, as such, can be altered by the City diversion. HES conducted an assessment of the relationship between flow and spawning habitat quality for steelhead and coho using PHABSIM (HES 2014b, Appendix 3: *Flow Studies*). The spawning habitat assessment was completed by measuring hydraulic conditions at 4 sites in the anadromous reach of Majors Creek and constructing computer models to predict changes in water depth, velocity, and substrate with discharge (HES 2014b).

The results of the habitat analysis for Majors Creek indicate that the spawning suitability index increases rapidly as flow increases from about 2 cfs and peaks at a flow of about 16 cfs (HES 2014b). Flows of 12 and 24 cfs provide 80% of the peak spawning suitability index for steelhead. Flows higher or lower than these levels result in increased frequency of depth, velocity, and substrate conditions that are outside the suitable range as defined by habitat suitability criteria used for steelhead or coho spawning (HES 2014b).

Rearing Habitat

The anadromous reach of Majors Creek provides relatively good quality rearing habitat with well-developed pools (Kawamoto Environmental Services (KES) 2001; ENTRIX, Inc. 2002, ENTRIX, Inc. 2004a). At a flow of approximately 0.8 cfs in the anadromous reach, without the City's diversion in operation, ENTRIX, Inc. (2004a) found habitat proportions in this reach were 60 percent pools, 37 percent runs, and 3 percent riffles. Extensive cover is available throughout the reach consisting of terrestrial vegetation, some boulder and cobble, and undercut banks (ENTRIX, Inc. 2004a). Mean pool depth was 0.9 feet and maximum pool depth averaged 1.8 feet (ENTRIX, Inc. 2004a). Observations by ENTRIX, Inc. (2002) in 2001 noted a few backwater pools with woody debris, which may provide high-flow refuge. Pools with openings in the canopy provided most of the suitable habitat for salmonids, where YOY and juveniles may feed efficiently by sight. The riffles in the anadromous reach tended to be short and heavily shaded (ENTRIX, Inc. 2004a).

Temperature monitoring data collected by the City indicates good water temperature conditions for rearing salmonids[18] (Figure 2-5) and comparable conditions to both Liddell and Laguna Creeks (Figure 2-1, Figure 2-2). Monthly average water temperature readings recorded from October 2019 through January 2020 peaked between June and September at 14°C to 15°C with monthly maximums peaking at 15°C to 17°C (Figure 2-2).

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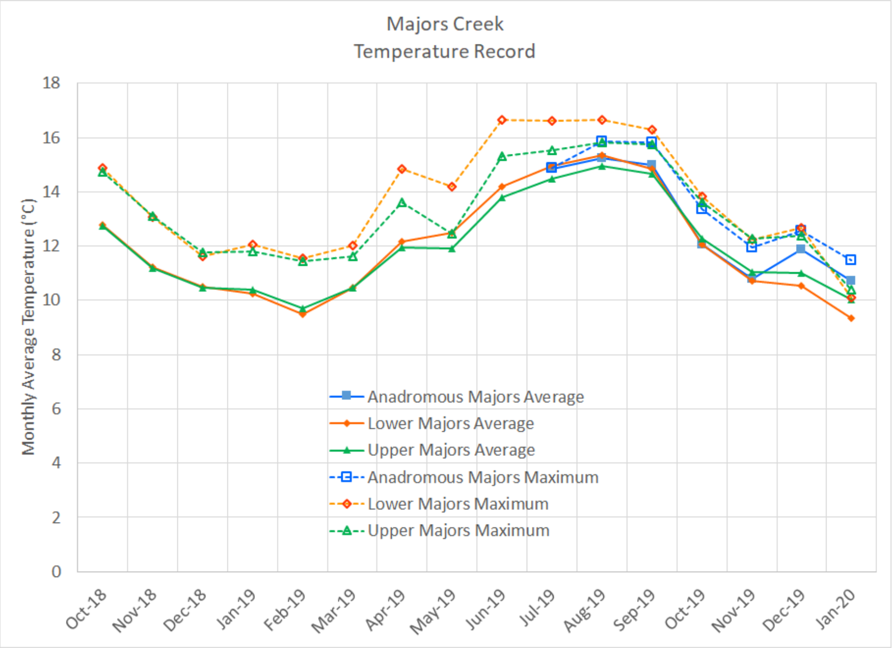
[18] See section 2.4.2.1 and HES 2014b for discussion of temperature tolerance for steelhead and coho.

Figure 2-5: Water Temperature in Majors Creek



During the winter of 2006-2007, HES conducted an assessment of the relationship between flow and rearing habitat quality using PHABSIM (HES 2014b, Appendix 3: *Flow Studies*). The rearing suitability index for steelhead increases gradually as flow increases from minimum levels and only begins to level out at the highest simulated flows of 18 to 20 cfs (HES 2014b). The rate of increase in the suitability index for steelhead rearing decreases with increasing flow and a flow of 5.5 cfs provides about 80% of the rearing suitability index for steelhead as that provided at a flow of 18 cfs. See Appendix 3: *Flow Studies*.

Lagoon Habitat

In a survey in June 2001, ENTRIX, Inc. (2002) found the Majors Creek Lagoon to be small, shallow, and with a sandy bottom devoid of any cover elements and concluded that the lagoon did not provide good rearing habitat for steelhead. PWA (2004) found the lagoon to be a small ponded area on the beach, approximately 5,000 square feet and only about 3 to 6 inches deep. There was no open outlet to the ocean and inflow into the ponded area was very small at the time of the survey (August 26, 2003). The available area for lagoon formation is very small and during late summer the lagoon on Majors Creek is about 0.1 acres (ENTRIX, Inc. 2004a). Based on this information, it is expected that the lagoon at the mouth of Majors Creek does not provide significant rearing habitat for steelhead.

2.4.3 San Lorenzo River Watershed Unit

The San Lorenzo River Watershed Unit is located within the larger San Lorenzo Watershed. Steelhead are present throughout this unit, except for portions of Newell Creek that may be inaccessible due to the presence of bedrock ledges (HES 2014b). The San Lorenzo River Watershed Unit is near the southern boundary of the Central California Coast Coho ESU. While small numbers of hatchery and wild coho have been observed in the trap at the Felton Diversion in past years, (possibly strays from nearby drainages with more persistent runs, including San Vicente, Scott and Waddell Creeks) coho have been presumed to be functionally extirpated from the San Lorenzo River since the drought of the late 1980s (Alley et al. 2004). A few coho were documented during 2005 in lower Bean Creek (DW Alley and Associates 2007) and two coho YOY coho were found the same year in Zayante Creek near the Bean Creek confluence (HES 2005c). Young of the year coho were also observed in snorkel surveys conducted by NMFS in Bean Creek that year (Chris Berry, City of Santa Cruz, personal communication to Jeff Hagar 2005). More recently, a coho carcass was found during spawning surveys in Bean Creek in 2015 (Jon Jankovitz, CDFW, personal communication to Chris Berry, 2020). The San Lorenzo River is considered potential habitat for coho and is managed accordingly. The majority of potential spawning and rearing habitat for coho is in the tributaries and upper mainstem, with the middle and lower mainstem serving primarily as a migration corridor.

2.4.3.1 Habitat Conditions San Lorenzo Mainstem

The San Lorenzo River watershed has a total drainage area of approximately 138 square miles. Suburban residential development in the watershed is extensive and urbanized areas occur along Highway 9. Land use authority for this development resides with the County of Santa Cruz and the City of Scotts Valley as of the late 1990s. Other land uses that occur within the basin include private timber harvesting, quarry activities, agriculture, and ranching operations. There are large tracts of state and municipal parks and recreation areas in the San Lorenzo River watershed. Streams in the San Lorenzo River watershed supplied water to over 100,000 residents in unincorporated communities and the cities of Santa Cruz and Scotts Valley (County of Santa Cruz 2001). Numerous municipal surface water diversions and groundwater wells, as well as other riparian and appropriative diversions, are scattered throughout the watershed (ENTRIX, Inc. 2004b).

Watershed/hydrology

The San Lorenzo River is a fifth order river flowing primarily to the south, which drains into the Pacific Ocean at the City. The elevation of the watershed ranges from sea level at the mouth to approximately 2700 feet at its headwaters. The approximate stream channel length of the mainstem from the mouth to its headwaters is 27.75 miles, of which there are approximately 26 miles of potential anadromous habitat. In addition, there are approximately 57 miles of anadromous habitat in tributary streams (ENTRIX, Inc. 2004b). See Figure 1-7: San Lorenzo Watershed Map.

The San Lorenzo River watershed has historically been a source of timber, minerals, recreation, and water resources. Since the 1950s, growth in the fulltime residential population, and related housing and infrastructure development has led to increased erosion and stream sedimentation, nutrient loading, stream flow reduction and habitat loss, water quality degradation and demand for water supplies (County of Santa Cruz 2001). In the 1970s, the watershed experienced a high rate of residential development, peaking at some 3,300 new units. The aggressive development contributed to water quality degradation from inadequate septic systems and urban runoff, increased levels of erosion and sedimentation, and alteration of wet and dry season runoff patterns (ENTRIX, Inc. 2004a). Negative impacts from urbanization are apparent throughout the lower San Lorenzo River watershed resulting in decreased habitat quality for salmonids (Alley et al. 2004).

Sedimentation from high levels of erosion can impair fish habitat and sedimentation has been identified as a significant negative impact on salmonid habitat quality in the San Lorenzo River since 1940 (California Department of Water Resources 1958, as cited in Swanson Hydrology & Geomorphology ((SH&G) 2001a). The San Lorenzo River Watershed Management Plan update reported that the greatest threat to aquatic habitat in the San Lorenzo is sedimentation (County of Santa Cruz 2001). A Regional Water Quality Control Board (RWQCB) staff report (RWQCB 2002) also identified sedimentation as the primary impact to aquatic habitats in the watershed. The San Lorenzo River is currently on the California 303(d) list for sediment impairment (ENTRIX, Inc. 2004b). In 2002 the Central Coast RWQCB adopted a Total Maximum Daily Load Plan (TMDL) for sediment in the San Lorenzo River (RWQCB 2002). Bed sedimentation has been reported by CDFW during stream surveys conducted in 1966 and in 1972 (ENTRIX, Inc. 2004a). Stream inventory surveys in San Lorenzo River tributaries conducted by CDFW in 1996 and 1997 reported the continued presence of extensive streambed sedimentation and numerous streamside sources of erosion (ENTRIX, Inc. 2004a). Work by Balance Hydrologics

(1998) indicated that the level of sedimentation in the San Lorenzo River had not improved since 1979 even though many erosion control measures had been implemented throughout the watershed and the pace of new development since the late 1970s had slowed considerably. Recent RWQCB work indicated improvements in several tributaries as of 2009 (Herbst, Medburst, Roberts, and Moore 2011), however this may not reflect current conditions subsequent to the historic storms of 2017. During the winter of 2017, the watershed experienced many landslide events and sediment transport was at a magnitude not seen since 1998 or earlier (East et al. 2018). In many stream reaches this translated as an overall coarsening of the bed, but in other stream reaches aggradation and subsequent embeddedness and pool filling occurred (Berry personal observation 2017).

Sources of sedimentation in the San Lorenzo River watershed appear to include both natural and anthropogenic processes. Extensive development in the sandhills geologic formations of the eastern side of the San Lorenzo watershed (e.g., Zayante Creek, Bean Creek and Carbonera Creek watersheds) has been implicated in substantial erosion and sedimentation in the lower portions of these tributaries as well as the middle and lower reaches of the San Lorenzo River (County of Santa Cruz 2001, Alley et al. 2004). Roads have been identified as likely primary sediment sources in other studies with unpaved or poorly maintained roads as the most persistent sources (Balance Hydrologics 1998, SH&G 2001a). Other sources of sediment include land clearing, disruption of riparian habitat, bank erosion, and landslides (ENTRIX, Inc. 2004a). A RWQCB staff report (RWQCB 2002) attributed 42% of the sediment loading to mass wasting, 29% to roads (including those associated with timber harvest activities), 15% to rural and urban lands, 14% to channel and bank erosion, and 0.4% to timber lands. According to the RWQCB (2002), the San Lorenzo River watershed is geologically pre-disposed to mass wasting with its steep slopes, high rainfall, and highly erosive geological formations (e.g. the Santa Margarita Formation). However, anthropogenic activities such as road building and construction activities can facilitate this process.

Nutrient loading is also an important issue for the San Lorenzo River. The issue of nutrient enrichment is particularly important for its effects in the San Lorenzo River Lagoon. Eutrophication of the lagoon affects rearing juvenile steelhead through effects on trophic relationships and water quality, including DO dynamics. Santa Cruz County adopted the San Lorenzo Nitrate Management Plan in 1995. The plan was used to develop an understanding of nitrate sources and transport. The plan findings and recommendations form the basis for the Nitrate TMDL Plan that was adopted by the Central Coast Regional Water Quality Control Board in 2000 (County of Santa Cruz 2001). The plan provides recommendations intended to reduce then current (2001) nitrate levels by 15 to 20 percent by 2010, with an additional 10 percent reduction in the following 10 years. Nutrient loading to the estuary may play a significant role in the quality and suitability of the estuary for steelhead rearing habitat (SH&G

2003) (ENTRIX, Inc. 2004b). According to a 2008 status report, observed nitrate trends show that reductions are occurring at a slower pace than desired, with an 11% decrease over the past 15 years. San Lorenzo River nitrate levels at Big Trees and the Tait Street Diversion during the period 2011-2017 also appear to be dropping slightly while they have risen slightly at Loch Lomond Reservoir (Kennedy Jenks Consultants, Inc. 2018). Ben Lomond and Boulder Creek sites have also experienced significant reductions of up to 60% recently. Although the 2008 status report suggested that "no significant adverse impacts resulting from nitrate loading at the current level have been identified" (Santa Cruz County 2008), given the potential effects on lagoon and riverine pool habitat eutrophication and on water storage at Loch Lomond Reservoir, nitrate trends will continue to be a consideration in the course of fisheries conservation planning.

The human population in the San Lorenzo River watershed relies exclusively on local surface water and groundwater supplies and water extraction is also an important factor in the health of aquatic habitats. Water demand is high enough during the dry season that the San Lorenzo River Watershed has been classified as fully appropriated for water supply between the months of June and October by the California State Department of Water Resources (ENTRIX, Inc. 2004b). A reduction in surface flow likely results in the reduced availability of spawning and rearing habitat in the tributaries and in the San Lorenzo River (County of Santa Cruz 2001, Alley et al. 2004).

In addition to the City's diversions, several other special districts or companies obtain water within the watershed (ENTRIX, Inc. 2004b) including:

- San Lorenzo Valley Water District (SLVWD) operates diversions on Fall, Lompico, Foreman, Harmon, and Peavine creeks, several springs and also operates several wells in the Santa Margarita aquifer; and
- There are more than 130 additional individual, private surface water diversions. See Figure 1-7: San Lorenzo Watershed Map.

In addition, groundwater pumping in the Bean Creek, Zayante Creek and Carbonera Creek watersheds is believed to influence baseflow in these streams and the San Lorenzo River (Alley et al. 2004). More recent observations indicate that flow in Bean Creek has been reduced 0.2-0.5 cfs by groundwater pumping (John Ricker personal communication to Chris Berry, 2019).

Instream Habitat

Migration Barriers

The entire Plan Area (Figure 1-1) in the San Lorenzo River mainstem is within the limits of anadromy for steelhead and coho. The limit of anadromy on Newell Creek is a short distance downstream of Newell Creek Dam and is discussed below. Migration past natural and anthropogenic passage obstacles in the San Lorenzo River mainstem may limit access by steelhead and/or coho to portions of the San Lorenzo Watershed, particularly in dry years or as a result of stream diversions. The following passage obstacles have been identified in previous work:

- Shallow riffles in the lower river downstream of the Tait Street Diversion
- Four Rock boulder field in the gorge
- Rincon Riffle in the gorge
- Shallow riffles in the vicinity of Henry Cowell State Park
- Felton Diversion Dam

Passage obstacles in the lower and middle mainstem of the San Lorenzo River (downstream of the Felton Diversion) are potential limiting factors for the entire River since they can restrict access to important spawning habitat in the tributaries (Alley et al. 2004). Good quality spawning habitat may be limited in the lower and middle River, so access to higher quality tributary spawning habitat upstream of the Felton Diversion is important to steelhead and coho abundance in both the mainstem and the tributaries (Alley et al. 2004). City operations may affect passage at some of these obstacles, either by reducing water in the river, or by the presence of physical structures associated with City facilities. The following describes what is known about flows necessary for salmonid migration at each of these obstacles.

The San Lorenzo River downstream from the Tait Street Diversion has been altered by urban development and for provision of flood control. Under low flow conditions, riffles in this reach can become very shallow and pose an obstacle to migrating steelhead and coho. The City diversion is limited in capacity but there are no required bypass flows downstream of the facility. During dry conditions, the flow in this reach and migration of steelhead and coho can be severely restricted. The relationship between flow and passage criteria (depth) in the 1.4 mile section from the Tait Street Diversion to the lagoon (roughly at Water Street) was evaluated by HES (2014b) through application of standard procedures commonly referred to as the Thompson method (Bjornn and Reiser 1991, Thompson 1972).

At four critical riffles in this reach, HES (2014b) determined that flows below the Tait Street Diversion between 17 and 25.2 cfs would provide conditions meeting standard depth criteria for adult migration (0.6 feet across 25% of channel width). Depth criteria for emigrating smolts would be met at flows of 3.8 to 10 cfs at the Tait Street Diversion (0.3 feet across 25% of channel width) (HES 2014b).

The Four Rock boulder field and Rincon Riffle in the San Lorenzo Gorge have been evaluated on several occasions. In most years, these locations are not passage problems, however, in drought years and years when storms are delayed, they can be serious barriers to steelhead and especially coho spawning migration (DW Alley & Associates 2009). Alley et al. (2004) estimated that flows of approximately 50-70 cfs would be required to meet passage criteria under the conditions observed in 2002. The assessment was based on the assumption that a minimum depth of 0.6 feet across 5 contiguous feet of channel width would be sufficient for adult passage (Alley et al. 2004). Alley also estimated that a flow of 35 cfs was probably sufficient to allow adult salmonid passage through the Gorge at all but these two sites.

During habitat surveys in 2008, it was discovered that the steep cascade at the base of the Rincon riffle had been altered by high flows and that conditions were much improved for fish passage up the main channel (DW Alley & Associates 2009). A project was also implemented by the Santa Cruz County Resource Conservation District in 2008 to alter the Four Rock barrier to improve conditions for fish passage.

The City conducted subsequent work based on the Powers and Orsborn methodology (Powers and Orsborn 1985) and showed that passage at the Four Rock site was likely possible by both coho and steelhead adults at 47 cfs since pool depths, jump distances, jump heights, high velocity reach lengths and water velocities were all within the capabilities of both species at this flow (Berry 2016).

Migration passage conditions were evaluated by CDFW biologist Paul Chappell who estimated that at a flow of 20 cfs, shallow riffles in the vicinity of Henry Cowell Park serve as partial barriers to migration while at 12 cfs they are complete barriers. The CDFW assessment concluded that a minimum flow of 40-50 cfs is needed to preserve the anadromous fishery (Ricker and Butler 1979).

At the request of the HCP Technical Team in 2016, the City also applied a desktop method utilized by CDFW (R2). The R2 results were comparable to the results of the Powers and Orsborn method and to results of the Thompson method at other sites, and to the conclusion of Chappell (Ricker and Butler 1979). The R2 estimate for suitable bypass flow for the San Lorenzo River in the vicinity of Four Rock was 39 cfs. This is consistent with the passage flow estimate of 40 cfs presented in the San Lorenzo Watershed Management Plan (based on Ricker and Butler 1979). This estimate is also consistent with the observation of large juvenile steelhead (to 316 mm FL) moving from the San Lorenzo River Lagoon upstream past the Felton Diversion during summer 2016 at flows of 26 cfs or less (Berry 2016). The analysis concluded that a flow of 39 cfs appears to be a reasonable adult migration flow estimate for the San Lorenzo River below the Felton Diversion. Since adult migration is usually the life stage requiring the most flow, this bypass flow should be protective of other life stages as well. These findings were accepted by the HCP Technical Team.

The Felton Diversion Dam may have caused passage difficulties at certain streamflows in the past. In 1994, CDFW raised concerns that adult fish may have trouble swimming over the dam when streamflow was low and the dam was deflated and that when streamflow was high, spill over the inflated dam may reduce the effectiveness of fish ladder attraction flows (ENTRIX 1997). The City, in coordination with CDFW, developed operating procedures to address these concerns (Appendix 4: *Felton Diversion Memoranda of Agreement (MOA)*).

The Felton Diversion is fitted with a Denil style fishway. The current operating practice allows for fish passage through the Denil fishway when the dam is inflated and passage over or around the dam when it is deflated. During the period from June through August when there is no diversion and when flow is less than 40 cfs during the diversion season, the dam is not inflated. During these periods all fish passage is over the deflated dam or around the deflated dam through the pumping channel. The MOA calls for inflation of small air bladders under both ends of the deflated dam to concentrate streamflow near the center of the deflated dam and provide a flow depth of at least 8 inches during the period of November 1 to June 15. Additionally, the dam is rarely inflated prior to mid-December due to operational constraints. At flows of approximately 300 cfs or greater, there was concern that the flow through the fish ladder is reduced relative to spill over the dam and insufficient to attract fish to the ladder. The MOA calls for supplemental attraction flow at flows greater than 300 cfs provided by partially opening a slidegate next to the fishway. If flow in excess of 300 cfs persists for 5 days and fish are observed holding below the dam, the dam is partially deflated to allow adult steelhead and coho to more easily leap over the dam.

The Denil fishway consists of several 4-foot-wide fabricated metal chute modules featuring incrementally spaced baffles of standard configuration. Typical of roughened chute style fishways, the baffles produce shear stress at the water column boundaries in a manner which generates high momentum exchange/energy dissipation and suitable hydraulic conditions conducive to fish passage (Buller 2006). The existing fish ladder is vertically aligned with a 16.7% slope or profile from entrance to exit. Wood Rogers calculated its maximum capacity at approximately 70 cfs at the maximum forebay water surface elevation (WSE) of El. 242.50. During operations when the forebay water surface is at the top of the inflatable dam (Forebay WSE = 240.50), the fishway conveys approximately 25 cfs (Buller 2006).

The Denil fish ladder design was conceived in the early 1900s and further developed through the 1930s and 1940s (Fulton et al. 1953). An early limited side-by-side comparison of a Denil fish ladder and a more widely used pool and weir fishway was conducted by the U.S. Fish and

Wildlife Service (USFWS) in the Wenatchee River (Fulton et al. 1953). The USFWS study found the Denil ladder was preferred by fish migrating during two migration seasons in the Wenatchee River. Fish species using the Denil ladder included sockeye salmon, Chinook salmon, rainbow trout, Dolly Varden trout, suckers, and pikeminnow. A comprehensive review of fish passage by the Food and Agriculture Organization (FAO) concludes that the success of Denil passes has been adequately proven for salmonids and cyprinids but that, from a more holistic ecological perspective, smaller fish and invertebrates including benthic macroinvertebrates that can ascend other types of ladders are excluded (FAO 2002). An advantage of the Denil pass is that it usually forms a good attraction current in the tailwater and is relatively insensitive to variations in tailwater elevation. However, suitable functioning of the Denil pass is highly susceptible to variation in the headwater level. Like many types of ladders, the Denil requires regular maintenance as clogging with debris can disrupt functionality. The FAO concludes that Denil passes should only be used where other structures cannot be built, for example due to lack of space, remoteness, or difficult access.

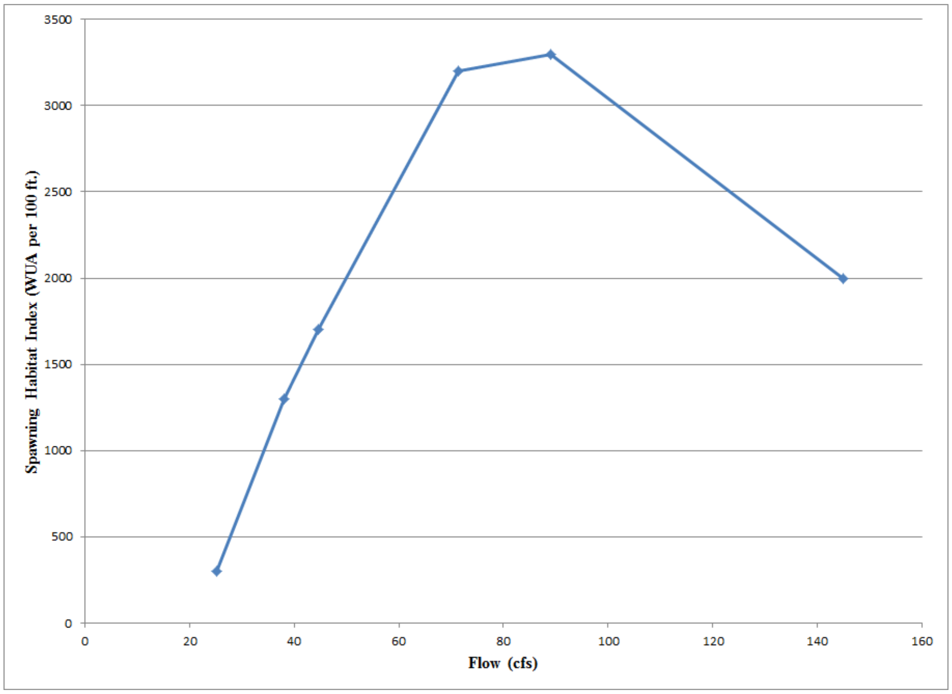
Spawning Habitat

The quality of spawning habitat varies greatly throughout the San Lorenzo River. Generally, spawning habitat quality is high enough, particularly in the tributaries and upper river, to allow returning fish to saturate the available habitat with fry (Alley et al. 2004). Spawning conditions in the middle and lower mainstem are poorer than other areas (Alley et al. 2004). According to Alley et al., the primary causes of poor quality spawning habitat or limited success of emerging fry are excessive fine sediment in spawning gravels that limit use of impaired areas by adult fish or cause egg or alevin mortality after spawning has occurred, and mobile bed conditions that result in loss of redds after spawning has already occurred. In the lower and middle River, poor spawning conditions exist due to the input of high fine sediment loads from tributary streams such as Boulder, Bear, Kings, Zayante, and Bean Creeks (Alley et al. 2004):

> Fine sediment from these tributaries is deposited in the lower gradient reaches, increasing the fraction of fine sediment at the terminus of pools where spawning gravels are typically found. High amounts of fine sediment deposition in the lower and middle river forces spawning adults to use areas dominated by sand that become mobile during late winter and early spring high flow events. In the case of tributaries, the variability of gradient and structural elements such as bedrock outcrops and large woody material may allow for good quality spawning habitat to exist in localized patches even if high fine sediment loads are present. Hydraulic variability created by these flow separators or constrictors allows fine sediment to be sorted and removed from certain locations, leaving higher quality gravel beds in their place that can be sought out by adult fish. (Alley et al. 2004)

Streamflow may also have some effect on the availability of spawning habitat. Ricker and Butler (1979) conducted instream flow studies to evaluate habitat conditions for steelhead in the San Lorenzo River and its tributaries. This work used a methodology that was a predecessor to the PHABSIM modeling used to develop bypass flows for the HCP. Data provided in Ricker and Butler (1979) for the reach near Henry Cowell Park indicates very low values of the suitability index at 25 cfs, a steep increase to a peak at 70 to 90 cfs, and a fairly steep decline from 90 cfs to about 60% of optimum at 145 cfs (Figure 2-6).

Figure 2-6: Relationship Between Flow and Spawning Habitat (WUA) Downstream of the Felton Diversion



Source: derived from data in Ricker and Butler 1979

Another indicator of flows that support good spawning habitat comes from the relationship between optimum[19] spawning flow and adult migration flow derived through PHABSIM studies

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[19] Optimum spawning flow refers to the peak of the WUA vs. discharge curve.

in other streams in the Plan Area (Table 2-9, data from HES 2014b). Since migration and spawning of steelhead and coho generally occur in close sequence during higher flows in winter, it is reasonable to expect that flow conditions conducive to both would be similar. Data from PHABSIM studies in other streams (Table 2-9) show a good correlation between minimum migration flow and optimum spawning flow for both steelhead and coho with optimum spawning flow at an average of 108% of minimum migration flow for steelhead and 84% of minimum migration flow for coho (Table 2-9, data from HES 2014b).

Table 2-9: Relationship Between Minimum Migration Flow and Optimum Spawning Flow

	Minimum Migration Flow (cfs)	**Steelhead Optimum Spawning Flow (cfs)**	**Percent of Migration Flow (steelhead)**	**Coho Optimum Spawning Flow (cfs)**	**Percent of Migration (coho)**
Liddell	11.3	13	115 %	9	80 %
Laguna	15.5	16	103 %	12	77 %
Majors	16.0	19	119 %	16	100 %
Newell	24.4	23	94 %	19	78 %
Average			*108 %*		*84 %*
Felton Diversion (*projected*)	39*	***42***		***34***	

Source: PHABSIM studies of streams in the Plan Area
* from Berry 2016

The analysis based on PHABSIM studies in other streams is consistent with the R2 method described previously. The peak of the Ricker and Butler curve (70-90 cfs) is significantly above either the R2 or PHABSIM comparison estimate, suggesting that optimum spawning conditions in the San Lorenzo mainstem downstream of Felton Diversion may occur at lower flows than indicated by the Ricker and Butler data. Indeed, there may have been changes to the channel since the Ricker and Butler work that could influence the relationship between flow and spawning habitat. The earlier data (Ricker and Butler) was collected in the 1970s and may reflect more degraded sediment conditions occurring closer to the period when industrial logging was ongoing and suburban development was at a peak. An assessment of streambed conditions and erosion control efforts in the San Lorenzo Watershed completed in 1998 concluded that streambed sedimentation had not improved significantly since 1979 despite various erosion control efforts that had been implemented (Balance Hydrologics 1998). More recently, a monitoring program for the San Lorenzo sediment TMDL found that sediment loads at comparable flows have declined by about 80% at Zayante Creek and 50% in the San Lorenzo River at Big Trees compared to rating curves developed in the 1970s and 1980s by the USGS (County of Santa Cruz 2019). The report also cites surveys by the USGS that found the record rainfall of 2017 triggered a change in sediment characteristics, towards coarser particle sizes and that the sediment load was significantly reduced in comparison to the record storms of 1982

(East et al. 2018). Another source of recent data from annual fish and habitat surveys between 2001 to 2019 shows no significant trends over that period for riffle and pool substrate embeddedness, percent fines, or pool depth in both the mainstem San Lorenzo River and tributaries (SCCWRP 2021, Beck et al. 2019). In summary, the USGS found a declining trend in sediment loads over the entire period from the 1970s to present but the two shorter-term studies for the period 1970-1998 (Balance Hydrologics) and 2001-2019 (Santa Cruz County) failed to detect any significant trend. The assumption we make here is that, while the channel has no doubt evolved and shifted in position, the features that determine the relation between flow and spawning habitat quality such as channel morphology (slope, bankful width, width to depth ratio, etc.) and mesohabitat features (riffle:pool proportion, cover, dominant substrate, etc.) fall in the same range as at the time of original survey. The Ricker and Butler data is used in the effects analysis (Chapter 5) since it provides a relationship between flow and spawning habitat suitability across a range of flows rather than just the optimum flow, and because it is based on a more extensive data collection effort. As a result, the effects analysis may somewhat overestimate the value of higher flows.

Rearing Habitat

The lower San Lorenzo River mainstem is influenced by Loch Lomond Reservoir and the Felton Diversion Dam and provides important rearing habitat for steelhead. Although the upper mainstem and tributaries have better spawning habitat than the lower and middle mainstem, steelhead juveniles experience slower growth rates in these areas due to lower temperatures and productivity. On the other hand, the warmer, more productive lower and middle mainstem support higher growth rates of juvenile steelhead where many YOY may reach smolt size in one growing season (Alley et al. 2004). Elevated water temperature below the lethal threshold can result in high growth rates given abundant food (Hokanson et al. 1977, Smith and Li 1983).[20] Alley et al. surmise that sufficient numbers of YOY steelhead are produced in the tributaries to move down into the mainstem and saturate rearing habitat there.

Water temperature and streamflow are major potential limiting factors for steelhead and coho in the San Lorenzo River. Response to temperature is complex and variable but for the purposes here we consider a temperature in the range of 16°C as optimal for rearing juvenile *O. mykiss* and in the range of 14.5°C as optimal for coho (see HES 2014b for additional information, Appendix 3: *Flow Studies*). Upper incipient lethal temperature for both species would be near 26°C. Average daily temperatures in excess of 19.3°C would be near the upper zone of suitability for juvenile steelhead and average daily temperature in excess of 18.3°C would be near the upper suitable zone for rearing coho (HES 2014b).

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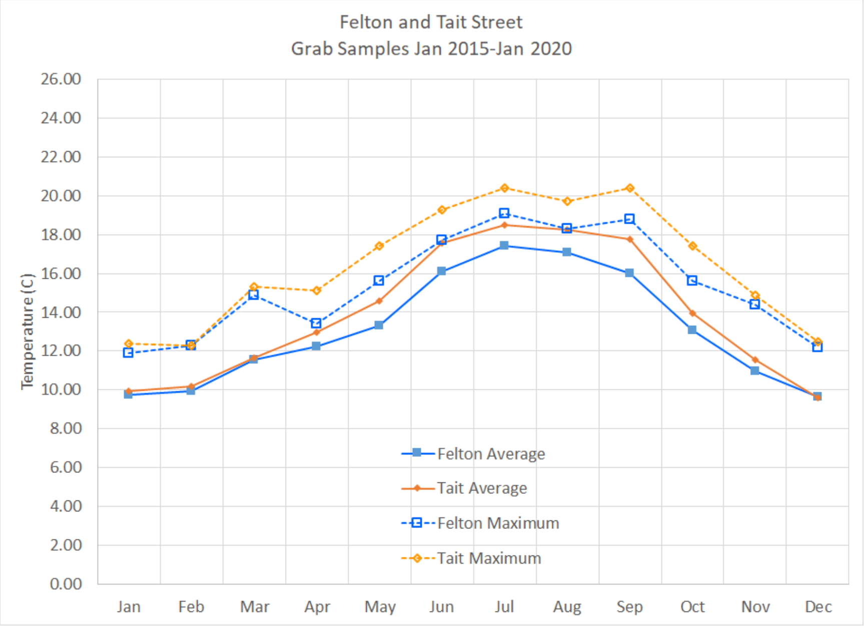
[20] See Section 2.4.2.1 and HES 2014b for discussion of temperature tolerance for steelhead and coho.

During a comprehensive survey in 2005, water temperature appeared suitable for steelhead at all monitoring locations but increased with distance downstream from Newell Creek and was near the upper range of suitability during the seasonal peak period and in the lower San Lorenzo River from above Tait Street Diversion to the lagoon (HES 2014b, Appendix 3: *Flow Studies*). Temperature is relatively warm for coho except in Newell Creek downstream of Newell Dam and Loch Lomond Reservoir. Suitability criteria for steelhead are generally met at all locations except the lower river. Temperature conditions are relatively warm upstream of the Tait Street Diversion and generally increase at Water Street (HES 2014b).

Newell Creek appears to have a moderating effect on temperature in the mainstem due to colder water released from Loch Lomond Reservoir to Newell Creek (see Section 2.4.3.2). During the summer months, there is a minimum release of 1 cfs from the Reservoir at an average temperature of 12°C to 14°C. Water temperature in the San Lorenzo River downstream of the Newell Creek confluence averaged approximately 1 degree cooler than water temperature immediately upstream of the confluence during the 2005 monitoring period (HES 2014b).

Water temperature at San Lorenzo River monitoring locations in 2005 (all downstream of the Felton Diversion) was lowest in the San Lorenzo Gorge (aka “Garden of Eden”) and increased at downstream locations. Water temperature conditions in August were near the upper range of suitability for steelhead and slightly in excess of the suitable range for coho (HES 2014b). Water temperature was highest at the Water Street monitoring location. None of the monitoring locations had maximum daily water temperatures that approached lethal levels for either steelhead or coho. None of the locations had daily average temperatures high enough to reach hypothetical zero yield for steelhead (see HES 2014b). All of the locations except the “Garden of Eden” had seven-day moving average of daily maximum temperature (MWAT) that exceeded suitability criteria for both steelhead and coho although, with the exception of Water Street, exceedances were only slightly above the criteria for steelhead. The MWAT criterion used (19°C) is a rather conservative criterion and does not account for potentially high food levels that ameliorate the effects of higher temperature (HES 2014b, Appendix 3: *Flow Studies*). Grab samples at the Felton Diversion and the Tait Street Diversion between January 2015 and January 2020 show that temperature is similar at these two locations in the winter but is warmer at the Tait Street Diversion by 1°Cto 2°C during the warmest months (Figure 2-7). The grab samples were collected in the morning and do not reflect higher afternoon temperatures.

Figure 2-7: Water Temperature Comparison at the Felton Diversion and the Tait Street Diversion Based on City of Santa Cruz Water Quality Lab Grab Samples



Water temperature recordings at the Tait Street Diversion from September 2014 through December 2019 (record from turbidity meter) and June 2014 through November 2018 (summer only HOBO data) indicate monthly average temperatures at the Tait Street Diversion of 20°C or less and monthly maximum temperature of 23°C or less (Figure 2-8 and Figure 2-9). These data are consistent with the 2005 data and indicate that water temperature can reach the upper edge of the suitability range for steelhead and exceeds the suitability range for coho.

Figure 2-8: Water Temperature at the Tait Street Diversion Based on City of Santa Cruz Turbidity Logger

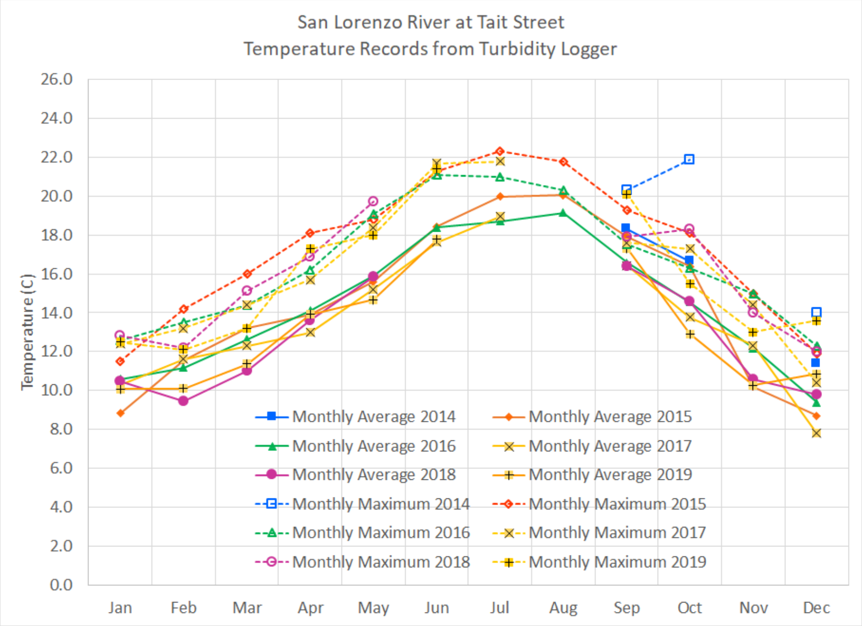
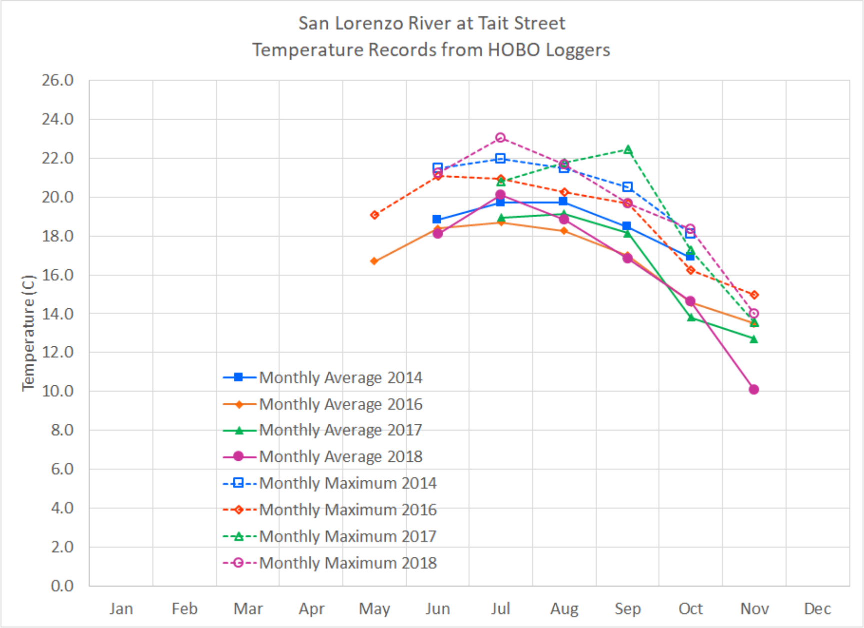


Figure 2-9: Water Temperature at the Tait Street Diversion Based on City of Santa Cruz HOBO Monitors



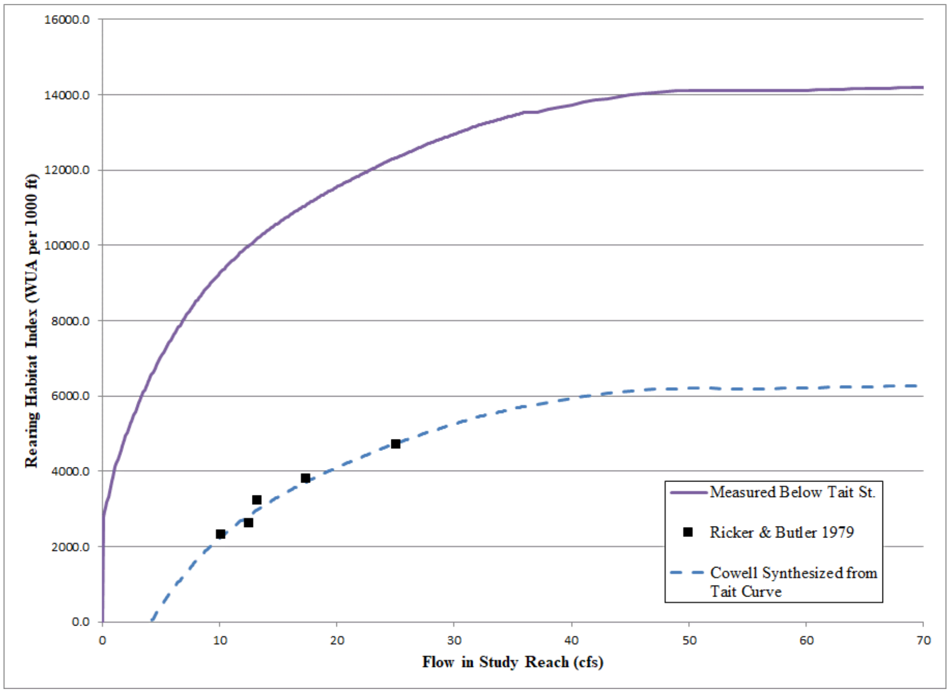
Water temperature was generally higher at Water Street than at the Tait Street Diversion with temperature differences ranging from -0.4°C to 1.9°C during the 2005 monitoring period (HES 2014b, Appendix 3: *Flow Studies*). The difference in temperature between the two locations was not correlated with flow in the observed range of 11 to 20 cfs. The temperature difference is likely explained by thermal gain in the relatively un-shaded flood control channel (FCC) upstream of Water Street (HES 2012b, Appendix 3: *Flow Studies*).

Potential riverine rearing habitat in the mainstem downstream of the Tait Street Diversion has been highly modified by construction of an FCC. The majority of riverine habitat suitable for rearing salmonids downstream of Tait Street is between Highway 1 and the lagoon, in the FCC (HES 2014b, Appendix 3: *Flow Studies*). Downstream of Highway 1, habitat consists primarily of relatively deep pools and runs with a small amount of relatively short riffles (HES 2014b, Appendix 3: *Flow Studies*). During a habitat survey in 2009, pools and runs downstream of Highway 1 were long and deep and comprised over 90% of the available habitat. The channel is confined with low, but relatively dense, overhanging riparian vegetation, including dense growths of young willows. The overhanging terrestrial vegetation and dense beds of floating aquatic vegetation provide good cover in the FCC. Between Highway 1 and Tait Street Diversion, the river is relatively wide, shallow and has a predominantly sandy substrate with depth and cover characteristics not as favorable for rearing salmonids. Habitat in the reach upstream of Highway 1 consisted exclusively of long shallow glide and long, relatively shallow run. The substrate upstream of Highway 1 was dominated by sand (90%) and silt (5%).

HES evaluated the relationship of instream flow and rearing habitat conditions in the San Lorenzo River between Tait Street Diversion and the lagoon (HES 2014b) using the PHABSIM model (Bovee et al. 1998). The index of rearing habitat (weighted useable area or WUA per 1000 feet of stream) for steelhead in this reach increases steeply from minimum levels at a flow of 0 cfs (HES 2014b)). As flow reaches 8 to 12 cfs, the rate of increase in WUA becomes less. WUA increases very little at flows greater than about 28 cfs. A flow of 16 to 18 cfs provides 80% of the maximum WUA in both sub-reaches (upstream of Highway 1 and in the FCC). Depth and velocity conditions in rearing habitat downstream of Tait Street were characterized as prime for steelhead at flow in excess of 19 cfs, good at flow of 8 to 19 cfs, fair at flows of 3 to 8 cfs and poor at flows of 3 cfs or less (HES 2014b). The San Lorenzo River downstream of Tait Street does not provide good rearing habitat for coho due primarily to high water temperature.

Ricker and Butler (1979) collected data on the relationship between flow and juvenile steelhead rearing habitat in the reach of the San Lorenzo River running through Henry Cowell Park. Transects were selected to be representative of the reach from the Felton Diversion downstream to Tait Street Diversion. Their data showed a consistent increase in habitat value (WUA) between 10 cfs and 25 cfs. To extend this dataset to higher and lower flows, the data were fit to the relationship developed for the reach of the San Lorenzo River downstream of Tait Street Diversion, adjusted to account for the number of transects used. This resulted in a good fit to the observed data (Figure 2-5). This relationship indicates that a flow of 26 cfs provides 80% of the measured maximum rearing habitat value. This is somewhat higher than the 19 cfs flow estimated to provide 80% of the maximum rearing habitat downstream of Tait Street Diversion (HES 2014b). The Ricker and Butler data also show WUA for summer rearing peaking at just under 20 cfs in the reach of the San Lorenzo River downstream of Boulder Creek. Coho are not likely to rear in the lower mainstem San Lorenzo as the cooler habitat they prefer is primarily in the tributaries. If they were in the lower mainstem, habitat values would peak at lower flows than steelhead due to preference of coho for lower flow velocities.

Figure 2-10: Relationship Between Flow and Steelhead Rearing Habitat (WUA) Downstream of the Felton Diversion



Source: Ricker and Butler 1979

Another indicator of flows that support good rearing habitat comes from the relationship between peak rearing flow and recommended flow for steelhead rearing derived through PHABSIM studies in other streams in the Plan Area (HES 2014b). These data show a good correlation between minimum migration flow and recommended rearing flow,[21] with recommended rearing flow at an average of 51% of minimum migration flow (Table 2-9, data from HES 2014b). The value for Tait Street Diversion may be anomalous since it partially reflects altered channel

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[21] Since rearing flow for steelhead can increase with flow without reaching a peak, recommended rearing flow was calculated as 80% of the WUA occurring at the penultimate (second highest) May average daily flow in the hydrologic record. May flow was used since this would be the highest flow during the summer rearing period and would presumably provide the best rearing habitat possible in the stream without any City diversion. The penultimate value was chosen because the highest value is often an outlier. For streams where the WUA vs. flow curve reaches a peak or asymptote the rearing flow was calculated as the flow where WUA reaches 80% of the peak or apparent asymptote value.

conditions in the FCC. The values provided are for steelhead; rearing suitability for coho peaks at lower flow levels than steelhead due to juvenile coho preference for lower flow velocity.

Table 2-10: Relationship Between Minimum Migration Flow and Optimum Rearing Flow

	Minimum Migration Flow (cfs)	**Recommended Rearing Flow (cfs)**	**Rearing/Migration Ratio**
Liddell	11.3	5.9	0.52
Laguna	15.5	6.9	0.45
Majors	16.0	6.7	0.42
Newell	24.4	9.9	0.41
San Lorenzo-Tait	25.2	18.8	0.75
Average for all streams			0.51
Felton Diversion (*projected*)	39*	***19.9***	

Source: PHABSIM studies of streams in the Plan Area
* from Berry 2016

The analysis based on PHABSIM studies in other streams supports the 20 cfs minimum bypass flow for rearing steelhead in the San Lorenzo mainstem downstream of the Felton Diversion, but indicates a slightly lower flow for optimum rearing conditions than indicated by the Ricker and Butler data. The Ricker and Butler data is used in the effects analysis (Chapter 5) since it provides a relationship between flow and rearing habitat suitability across a range of flows rather than just the optimum flow, and because it is based on a more extensive data collection effort. As a result, the effects analysis may somewhat overestimate the value of higher flows for rearing.

Lagoon Habitat

A description of general lagoon dynamics for the Plan Area has been presented in Section 2.4.2.2 (Habitat Conditions Laguna Creek) and that discussion applies to the San Lorenzo River Lagoon as well. The San Lorenzo River Lagoon provides extremely important habitat for steelhead in the Plan Area and for the CCC Steelhead DPS as a whole. Every steelhead in the San Lorenzo River Basin uses the lagoon for either rearing, migration or both. A large portion of the basin’s steelhead spawning population likely uses the lagoon as rearing habitat. Coho also migrate through the lagoon, both as smolts and adults, although lagoon rearing does not appear to be as important for coho as it is for steelhead.

The San Lorenzo River Lagoon has been highly modified compared to historic conditions. Direct modifications include urban encroachment, marsh filling, railroad and road crossings, and levee construction, all resulting in significant reduction in the areal extent and volume of the lagoon. San Lorenzo River Lagoon habitat has been highly altered and is missing components favorable to steelhead rearing such as fringing marsh vegetation, riparian canopy, and fallen large tree trunks that may provide important cover.

The areal extent of the San Lorenzo River Lagoon has been reduced by 80% through mudflat filling and levee construction (2ndNature 2006). These physical modifications have changed the tidal prism,[22] the timing and duration of sandbar closure, the aquatic vegetation communities, and likely, many biotic processes. The urban development and other modifications within the contributing catchment of the San Lorenzo River Lagoon have increased nutrient loading, altered sediment delivery, and altered hydrologic patterns. Artificial summer sandbar breaching for flood-control alters water quality parameters and may influence the potential for steelhead to rear in the lagoon. This breaching activity appears to be limited to the San Lorenzo River lagoon. Water withdrawals have also altered the seasonal dynamics of the lagoon. Sorting out the influence of any single factor on habitat conditions in the lagoon, such as changes in freshwater inflows, is not easily accomplished. One of the primary processes of concern in the San Lorenzo River Lagoon is degradation of water quality conditions during the summer lagoon closures. In particular, sustained low DO concentrations and elevated water temperatures impact lagoon ecology and influence the productivity of steelhead and coho populations.

Studies by Smith (1990) and more recent studies in the San Lorenzo Lagoon and other Central Coast lagoons (SH+G 2001b, 2ndNature 2006, 2ndNature 2008, 2ndNature 2009a, 2ndNature 2009b, 2ndNature and HES 2016) suggest that the dynamics of habitat quality for rearing salmonids in the lagoon are complex and that many factors, including the timing of sandbar closure, freshwater inflows, tidal exchange, nutrient enrichment, nitrogen availability, lagoon morphology, water temperature, and water clarity may strongly influence the water quality conditions during the dry season and suitability of the lagoon for rearing juvenile steelhead.

Sandbar Formation

The modifications to the San Lorenzo Lagoon discussed previously have resulted in limited ability for the lagoon to expand horizontally and therefore, there is a strong relationship between lagoon inflow and elevation. Data from the lagoon monitoring studies show that the San Lorenzo River mouth can go through a number of closures and breaches during each dry season (May 15 through October 31 for this analysis) (2ndNature 2006, 2008, 2009a, 2009b, 2009c, 2010a, 2010b, 2011, 2012, 2013, 2014, 2015, 2016). In some instances, the breaches are natural due to water in the lagoon exceeding the elevation of the sandbar and some are due to illegal manual breaches of the mouth by surfers, beach goers or other entities. In any case, the lagoon

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[22] The volume of water that flows into a tidal channel and out again during a complete tidal cycle.

cannot be opened manually without great effort and large equipment unless the water surface elevation is very near the beach crest elevation and close to breaching naturally.

Results of water quality sampling for the years from 2002 to 2015 (except 2006) indicate that relatively wetter water years, and higher stream flow discharge in August, do correspond with relatively shorter durations of sand bar closure at the mouth of the San Lorenzo River (Table 2-11). During the years with highest precipitation and highest August inflow to the lagoon (2005 and 2011), the lagoon was open the entire season. During years with lower inflow in August (2007-2009, 2014, and 2015), the lagoon was closed for greater amounts of time.

Sandbar closure has also been influenced by construction of the Santa Cruz small craft harbor jetty in 1963 (Griggs 2012). The 1200-foot-long west jetty creates a nearly complete trap for sand moving southeast along the coast as part of a littoral cell originating near Pillar Point in San Mateo County and terminating in the Monterey Submarine Canyon in central Monterey Bay (Griggs 2012). This has led to the widening of Seabright Beach, immediately east of San Lorenzo Point, and main beach, where the San Lorenzo River enters the ocean. On average, main beach has been widened by 140 to 150 feet and under low flow conditions the river is not able to maintain its path across this wider beach and a sandbar forms more frequently, damming the river (Griggs 2012). In addition, since the outer edge of the sandbar is higher than the back beach, the rising lagoon extends along the back beach to the west, in front of the boardwalk. Due to resulting flooding, the City has had to resort to manually opening and draining the lagoon at higher lagoon stages. In low flow years this process has had to be repeated as often as several times during the dry season. The City has now proposed to install a culvert through which the lagoon can be maintained at a determined elevation without serious flooding or the need for mechanical breaching (Environmental Sciences Associates 2018).

Table 2-11: Timing and Duration of San Lorenzo River Lagoon Sandbar Closure

	Water Year precipitation (in)[1]	August Average daily San Lorenzo River discharge to Lagoon (cfs) [2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)	Number of days microtidal May 15 to Oct. 31 (168 days in period)[3]	Mean of daily average water depth at YSI site (June-Aug)
2004	35.49	6.8	19-Jul	N/A	45 (27%)	20 (12%)	4.32
2005	64.83	22.1	Never closed	N/A	0 (0%)	56 (33%)	3.95
2006	67.78	29.8	N/A	N/A	N/A	N/A	N/A
2007	25.4	3.4	23-May	N/A	89 (53%)	32 (19%)	5.16
2008	39.6	2.3	26-Jul	26-Jul	97 (57%)	15 (9%)	4.99
2009	36.52	2.1	15-Jun	28-Jul	87 (51%)	13 (8%)	5.04
2010	48.88	12.4	4-Jul	4-Jul	60 (37%)	18 (11%)	4.68
2011	62.15	25.8	31-Aug	2-Nov	11 (7%)	35 (21%)	3.36
2012	34.35	9.0	23-Jul	27-Oct	54 (32%)	25 (15%)	3.20
2013	36.2	9.5	17-May	23-Oct	114 (67%)	12 (7%)	4.91
2014	24.5	1.9	15-May	17-Jul	151 (89%)	N/A	N/A
2015	35.5	4.1	15-May	22-June	149 (88%)	N/A	N/A
2016	48.6	9.8	6-June	23-June	19 (11.2%)	114 (67.5%)	N/A

Source: 2NDNATURE

N/A not available, no monitoring performed or limited data

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz, average Q integrated over one day.

[3] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

Lagoon Circulation Regime and Water Quality

Continuous monitoring of water quality (salinity, DO, temperature, pH, and depth) from two sites in the lagoon provide an indication of the dynamic nature of water quality in the lagoon. The lower site is located in deep water near the bend upstream from the railroad bridge. This site is more influenced by tidal exchange than more upstream locations. The upper site is located in deep water upstream of Riverside Bridge. Recording began at the lower site in approximately 2002, with the upper site added in 2014. Water quality data is recorded at the surface and at the bottom at both sites (2ndNature 2006). See Figure 2-6: San Lorenzo River Lagoon Water Quality Monitoring Locations.

Salinity in the San Lorenzo River Lagoon is highly dynamic though there is generally some degree of salinity at the lower water quality monitoring site most of the time during the June-October time period, both in surface and bottom waters (Table 2-12). Surface salinity is generally higher in the June-August period, when the lagoon is more likely to be open, than in the September-October period when the lagoon is either closed or tidal exchange is reduced. The lowest levels of surface salinity have been observed in 2005 and 2011 under conditions of an open lagoon and relatively high freshwater inflow. Bottom waters nearly always have salinity of at least 5 ppt. Only in 2005, with relatively high freshwater inflows, were there some observations of salinity less than 5 ppt.

Figure 2-11: San Lorenzo River Lagoon Water Quality Monitoring Locations

Table 2-12: Salinity Conditions from Continuous Monitoring Record at Lower Monitoring Location in the San Lorenzo River Lagoon in Comparison to Freshwater Inflow and Timing and Duration of Sandbar Closure

	Water Year precipitation (in)[1]	August Average daily San Lorenzo River discharge to Lagoon (cfs)[2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)[3]	Number of days microtidal May 15 to Oct. 31 (168 days in period)[4]	% of observations of surface salinity > 5 ppt (June-Aug)	% of observations of bottom salinity > 5 ppt (June-Aug)
2004	35.49	6.8	19-Jul	N/A	45 (27%)	20 (12%)	98%	100%
2005	64.83	27.1	Never closed	N/A	0 (0%)	56 (33%)	27%	88%
2006	67.78	29.8	N/A	N/A	N/A	N/A	N/A	N/A
2007	25.4	3.4	23-May	N/A	89 (53%)	32 (19%)	68%	100%
2008	39.6	2.3	26-Jul	26-Jul	97 (57%)	15 (9%)	81%	100%
2009	36.52	2.1	15-June	28-Jul	87 (51%)	13 (8%)	81%	99%
2010	48.88	12.4	4-Jul	4-Jul	60 (37%)	18 (11%)	51%	99%
2011	62.15	25.8	31-Aug	2-Nov	11 (7%)	35 (21%)	38%	87%
2012	34.35	9.0	23-Jul	27-Oct	54 (32%)	25 (15%)	40%	100%
2013	36.2	9.5	17-May	23-Oct	114 (67%)	12 (7%)	N/A	100%
2014	24.5	1.9	15-May	17-Jul	151 (89%)	N/A	89%	100%
2015	35.5	4.2	15-May	22-June	149 (88%)	N/A	78%	100%
2016	48.6	9.8	6-June	23-June	19 (11.2%)	114 (67.5%)	18%	46%

Source: 2NDNATURE

N/A not available, no monitoring performed, or limited data

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz.

[3] Sandbar closure is determined from visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[4] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

The extended periods of lagoon closure in 2007-2009, 2014, and 2015 were associated with the highest temperatures in both surface and bottom waters (Table 2-13). It might be expected that lagoon water temperature would be correlated with atmospheric temperature and there is some support for this in the data (Table 2-13) however, there are also exceptions such as 2014 which had relatively lower air temperature but some of the warmest water temperature. If air temperature is a factor it appears less important than tidal exchange (Table 2-13).

Table 2-13: Water Temperature Conditions from Continuous Monitoring Record in the San Lorenzo River Lagoon in Comparison to Freshwater Inflow and Timing and Duration of Sandbar Closure

	Water Year precipitation (in)[1]	August Average daily San Lorenzo River discharge to Lagoon (cfs) [2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)[3]	Number of days microtidal May 15 to Oct. 31 (168 days in period)[4]	Average of Daily Maximum Air Temperature (°C)[5]	Maximum Weekly average Temperature (MWAT)	Number of Days with Average Surface Temperature Exceeding 19°C. (June-Aug)	Number of Days with Daily Average Surface Temperature Exceeding 21°C. (June-Aug)	Number of Days with Daily Maximum Surface Temperature Exceeding 25°C. (June-Aug)
2004	35.49	6.8	19-Jul	N/A	45 (27%)	20 (12%)	21.5	23.5	44 (75%)	18(31%)	4(7%)
2005	64.83	27.1	Never closed	N/A	0 (0%)	56 (33%)	20.8	21.5	54 (64%)	7(8%)	3(3%)
2006	67.78	29.8	N/A	N/A	N/A	N/A	21.8	N/A	N/A	N/A	N/A
2007	25.4	3.4	23-May	N/A	89 (53%)	32 (19%)	22.2	23.0	61(85%)	26(33%)	21(27%)
2008	39.6	2.3	26-Jul	26-Jul	97 (57%)	15 (9%)	22.0	24.2	69(80%)	35(38%)	29(32%)
2009	36.52	2.1	15-June	28-Jul	87 (51%)	13 (8%)	21.7	24.4	69(80%)	39(42%)	14(15%)
2010	48.88	12.4	4-Jul	4-Jul	60 (37%)	18 (11%)	20.6	21.4	37(48%)	8(10%)	1(1%)
2011	62.15	25.8	31-Aug	2-Nov	11 (7%)	35 (21%)	19.9	20.5	14(17%)	1(1%)	1(1%)
2012	34.35	9.0	23-Jul	27-Oct	54 (32%)	25 (15%)	21.1	21.0	55(64%)	9(10%)	6(7%)
2013	36.2	9.5	17-May	23-Oct	114 (67%)	12 (7%)	21.7	N/A	N/A	N/A	N/A
2014	24.5	1.9	15-May	17-Jul	151 (89%)	N/A	21.3	25.6	84(98%)	79(86%)	59(64%)
2015	35.5	4.2	15-May	22-June	149 (88%)	N/A	23.6	25.4	79(92%)	77(84%)	61(66%)
2016	48.6	9.8	6-June	23-June	19 (11.2%)	114 (67.5%)	20.9	23.3	75(87%)	53(58%)	3(3%)

Source: 2NDNATURE

N/A not available, no monitoring performed, or limited data

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz.

[3] Sandbar closure is determined from visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[4] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[5] Air temperature data provided by CIMIS website (https://cimis.water.ca.gov/). Data represents an average of two weather stations: DeLaveaga station (#104) is located in Santa Cruz, CA at an elevation of 91.4 MSL and Pajaro station (#129) is located adjacent to the Pajaro River at 65 MSL.

Steelhead are generally expected to survive and grow well at temperature up to about 19°C to 21°C if food is abundant. Steelhead may actually grow faster at higher temperatures if food is abundant (Smith and Li 1983) but at temperature in excess of 21°C, increased mortality may offset the benefits of increased growth rates at the population level Hokanson et al. 1977). Food levels are generally high in Central Coast lagoons and should allow steelhead to thrive at relatively high temperatures. Temperatures of 25°C to 26°C are generally considered lethal (Bidgood and Berst 1969, Hokanson et al. 1977) (see HES 2014b for discussion of temperature suitability). Based on the temperature record from the San Lorenzo River Lagoon, lethal temperature conditions occurred at the surface[23] in every year but the frequency of lethal conditions was highest in 2007-2009, 2014, and 2015 when the lagoon was closed for extended periods (Table 2-13). These warm temperatures at or above the lethal threshold are associated with the lowest catch rates of steelhead in monitoring conducted in the fall (Table 2-13, Table 2-15, Table 2-16) including zero captures in 2014 and 2015, the years with highest surface water temperature and highest frequency of potentially lethal conditions.

Daily average temperature appears to be quite warm for steelhead in all years with a large number of days exceeding 21°C at the surface during the June-August period (Table 2-13). Temperature conditions are more moderate in the September-October period. The seven-day moving average of daily maximum temperature also exceeds 19°C frequently in all years. In stream type environments, this would indicate less than optimal conditions for rearing steelhead (see HES 2014b for discussion of temperature suitability). See Appendix 3: *Flow Studies*.

It is notable that the number of days with seven-day average of maximum temperature exceeding 19°C in 2005 was comparable to 2007 and 2008 but that number of days with daily average surface temperature exceeding 21°C was much lower and with only three days exceeding the lethal threshold in 2005 (compared to 21 and 29 days in 2007 and 2008) (Table 2-9). This, in combination with the fact that the standard deviation of temperature statistics was much lower in 2005 compared to 2007 and 2008, indicates that temperature extremes can be moderated under open lagoon conditions (Table 2-13).

It is more difficult to discern patterns of DO concentration relative to lagoon closure and inflow. Optimal DO levels for steelhead are 7 mg/l and above, although levels down to about 5 mg/l can be tolerated (US EPA 1976, US EPA 1986, Raleigh et al. 1984). Suitability falls off rapidly at levels below 5 mg/l and the incipient lethal level is approximately 3 mg/l or less, depending on environmental conditions, especially temperature (Raleigh et al. 1984).

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[23] Water can sometimes be cooler with greater depth in the lagoon, however low DO and higher salinity may preclude steelhead from retreating there.

In the San Lorenzo River Lagoon, DO at the bottom of the water column was generally less than 5 mg/l most of the time regardless of closure or inflow conditions (Table 2-14). DO at the surface is a parameter that has great potential for discriminating between different closure/inflow conditions, but it was not consistently measured in the San Lorenzo River Lagoon in the initial monitoring period. For years with surface DO measurements, there are a substantial number of days with minimum daily surface DO concentration of 5 mg/l or less. There appears to be no good correlation between surface DO levels and either lagoon inflow in August or duration of lagoon closure. The lowest occurrences of DO concentrations of 5mg/l or less were in 2012, with high lagoon inflow and minimal closure, and 2014 and 2015 with low inflow and extended lagoon closure (Table 2-14).

Table 2-14: Dissolved Oxygen Conditions from Continuous Monitoring Record in the San Lorenzo River Lagoon in Comparison to Freshwater Inflow and Timing and Duration of Sandbar Closure

	Water Year precipitation (in)[1]	August Average daily San Lorenzo River discharge to Lagoon (cfs)[2]	Date of initial sandbar closure	Date of final sandbar closure	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)[3]	Number of days microtidal May 15 to Oct. 31 (168 days in period)[4]	Number of days with minimum daily surface DO 5 mg/ l or less (June-Aug).	Number of days with minimum daily bottom DO 5 mg/ l or less (June-Aug).	% of observations of surface DO <=7 mg/l (June-Aug).	% of observations of bottom DO <=7 mg/l (June-Aug).
2004	35.49	6.8	19-Jul	N/A	45 (27%)	20 (12%)	N/A	57	N/A	71%
2005	64.83	27.1	Never closed	N/A	0 (0%)	56 (33%)	N/A	87	N/A	79%
2006*	67.78	29.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2007	25.4	3.4	23-May	N/A	89 (53%)	32 (19%)	N/A	92	N/A	94%
2008	39.6	2.3	26-Jul	26-Jul	97(57%)	15 (9%)	89	92	50%	91%
2009	36.52	2.1	15-June	28-Jul	87 (51%)	13 (8%)	67	65	37%	86%
2010	48.88	12.4	4-Jul	4-Jul	60 (37%)	18 (11%)	77	92	60%	71%
2011	62.15	25.8	31-Aug	2-Nov	11 (7%)	35 (21%)	60	73	37%	45%
2012	34.35	9.0	23-Jul	27-Oct	54 (32%)	25 (15%)	43	92	33%	67%
2013	36.2	9.5	17-May	23-Oct	114 (67%)	12 (7%)	N/A	89	N/A	66%
2014	24.5	1.9	15-May	17-Jul	151 (89%)	N/A	43	77	28%	64%
2015	35.5	4.2	15-May	22-June	149 (88%)	N/A	33	81	20%	63%
2016	48.6	9.8	6-June	23-June	19 (11.2%)	114 (67.5%)	62	92	37%	91%

Source: 2NDNATURE

N/A not available, no monitoring performed, or limited data

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz.

[3] Sandbar closure is determined from visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[4] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

Of course, salinity, temperature, and DO are all inter-related to some degree. Cooler water holds more DO and the rate of biological processes that produce and consume DO are also temperature related. Nutrients and light availability are also significant factors. Higher temperature increases the potential maximum photosynthetic rates if light availability and nutrient supply are not limiting (Wetzel 2001).

The combination of relatively warm temperature and high nutrient availability result in a highly productive lagoon during the summer and early fall closures. The limiting nutrient in all Santa Cruz County lagoons evaluated during the CLEAP study is nitrogen (2ndNature 2006). The San Lorenzo River Lagoon has average surface water dissolved nitrate (NO_3^-) concentrations on the order of 30 um, or 0.4 mg/L (2ndNature 2001, 2003, 2006, 2008, 2009a), consistently higher than those observed in other Santa Cruz County lagoons evaluated in the CLEAP study (2ndNature 2006). While nitrate levels in the San Lorenzo River Lagoon do not exceed human health standards, they are relatively elevated from an aquatic ecosystem perspective and contribute to increased eutrophication (primary production rates) associated with increased production of phytoplankton and algal growth.

The increased biological production of phytoplankton and algal species in the surface waters produces oxygen through photosynthesis during daylight while biological respiration in the bottom waters (where light does not penetrate) and during night consumes oxygen. Even under conditions where the water column is not stratified, concentration of DO in the bottom waters can become depleted if the consumption of oxygen by respiration exceeds the supply of oxygen in the water column. Strong salinity (or thermal) stratification can exacerbate the low DO conditions in the bottom waters since the stratification prevents oxygen produced by photosynthesis in the upper water column from replenishing the oxygen that is consumed through respiration in the bottom waters. Depletion of DO in bottom waters is a common feature in highly productive aquatic systems, particularly, though not exclusively, when the water column is physically stratified by a thermal or salinity gradient. It can occur in fresh-water lakes, other lagoons in Santa Cruz County, and other non-stratified lagoons (Brock 1985, Burgi and Stadelmann 2002, Jónasson et al. 1974, Riemann and Søndergaard 1986, Søndergaard et al. 2005).

Low DO concentration is observed when a strong halocline is present. However, in a number of instances the San Lorenzo Lagoon also has low DO concentrations (<3 mg/L) in the bottom waters when the lagoon is unstratified with a relatively freshwater column (2ndNature 2008, 2009). The simultaneous occurrence of a freshwater column yet poor DO in the bottom water suggests that the nutrient availability and resulting primary production is exceeding the DO supply available (2ndNature 2006).

Another local Santa Cruz lagoon, Soquel Creek Lagoon, is manually closed in early summer each year in a manner that ensures a completely freshwater lagoon. Some form of this practice in Soquel Lagoon dates back to the early 1900s. The water quality in the Soquel Creek Lagoon is typically better for rearing steelhead than in the San Lorenzo River Lagoon, specifically lower surface water temperatures and higher DO concentrations. However, nitrate loads in the San Lorenzo River Lagoon are an order of magnitude higher than those observed in the significantly smaller Soquel Creek Lagoon (SH&G 2001b). The better DO levels in the Soquel Creek Lagoon during the summer closure conditions may be attributed to the combination of lower nitrate loading and the dense riparian canopy that keeps surface water temperatures on average 3-4ºC cooler than San Lorenzo and Aptos Lagoons (2ndNature 2006). Chlorophyll concentrations are also consistently lower in Soquel, and there is also less accumulation of organic detritus on the bed of the lagoon at the end of the summer season (2ndNature 2006). It is not merely the closure of the lagoon and resulting fresh-water column in the Soquel Creek Lagoon that provides conditions more conducive to rearing steelhead, but the fresh water column, in combination with lower temperature and higher DO levels associated with the lower nutrient loading and dense riparian canopy in the Soquel Creek Lagoon.

There remains some question as to how water quality conditions in the San Lorenzo River Lagoon would respond to forced closure with a culvert system similar to that practiced in Soquel Creek. A condition of sustained closure and moderate fresh water inflows has not been observed in the San Lorenzo River Lagoon. As previously discussed, sustained closures are not compatible with higher summer inflows due to the process of lagoon filling, spilling, and breaching. Bottom waters have only infrequently been observed with salinity below 5 ppt during the years when monitoring has occurred, and never during years when the lagoon was closed. Continued monitoring suggests warmer temperature under closed lagoon conditions and that the high primary production rate (supported by high nutrient availability) may exceed the supply of oxygen in the water column even in unstratified conditions (SH+G 2001b, 2ndNature 2006, 2008, 2009.

Habitat Conditions and Steelhead Abundance Surveys

Steelhead juveniles have been captured in the San Lorenzo River Lagoon during monitoring in 2002 (H.T. Harvey and Associates 2003b), 2004, and 2005 (2ndNature 2006), and since 2008 (HES 2009a, HES 2010, HES 2011a, HES 2012, HES 2013, HES 2014a, HES 2015, and HES 2016, HES 2017, HES 2018, HES 2019). Steelhead have been found rearing in the lagoon in every year when sampling has been conducted (Table 2-15). Abundance has been measured by two methods: CPUE and mark-recapture abundance estimates. CPUE is simply the total number of *O. mykiss* caught divided by the number of seine hauls completed (Table 2-15). In theory, if there are more fish in the lagoon, more will be caught with each haul and CPUE will be higher.

CPUE estimates are available for every year. The second estimate of abundance is an estimate of the actual number of *O. mykiss* obtained by marking fish initially and then observing the proportion of marked fish in a subsequent recapture period. Mark-recapture estimates have been made since 2011 (Table 2-16). Both methods have advantages and disadvantages. CPUE estimates work best when "catchability" is constant. Seining in the lagoon occurs under a variety of conditions of lagoon stage and beach access and catchability may be variable. Mark-recapture is less sensitive to catchability, but the method assumes that marked fish are evenly distributed in the population and that there is no movement in and out of the lagoon during the period between marking and recapture. The assumption of even distribution may be approximately achieved but we have indications that fish are sometimes moving in and out of the lagoon, even during the relatively short survey periods. Never-the-less, both methods give a reasonable index of abundance and both have been correlated with each other. It is certainly possible to determine when *O. mykiss* are abundant in the lagoon and when they are not.

Table 2-15: Steelhead CPUE for the San Lorenzo River Lagoon by Month and Year

	Steelhead Catch per Haul				
Year	**June**	**July**	**August**	**September**	**October**
2002[1]					12.8
2004		21.9		0.10	
2005[1]	8.9	4.6	48		15.7
2008	2.6				0.1
2009	0.3			1.0	0.5
2010	8.3	21.5			28.25
2011	13				2.5
2012	1.7			14.4	
2013	2	8.4		4.7	
2014	1.2	1.1		0	
2015	2.6	0	0		0
2016	39.7	1.0	2.0	7.8	
2017	134.4	452.0	272.0	328.5	
2018	23.3	2.5	6.4	6.3	

Source : data from H.T. Harvey and Associates 2003, 2NDNATURE 2006, Ellen Freund (NMFS), HES 2005, HES 2009, HES 2010, HES 2011, HES 2012, HES 2013, HES 2014a, HES 2015, HES 2016, HES 2017, HES 2018, and HES 2019)

[1] Data are averaged between sites.

Table 2-16: Steelhead Mark-Recapture Population Abundance Estimates in San Lorenzo River Lagoon

	Steelhead Population Estimate	
	Spring	**Fall**
2011	501	138
2012	60	714[1]
2013	207[2]	No estimate[3]
2014	No estimate[4]	None captured
2015	559[3]	None captured
2016	2697	1331
2017	3636	>3636[5]
2018	2378	704

Source: data from HES 2012, HES 2013, HES 2014a, HES 2015, and HES 2016

[1] May have been fish entering or leaving lagoon

[2] Low number of marks or recaptures, likely biased

[3] Evidence population not closed, violates assumption of the method

[4] No recaptures

[5] Estimate based on CPUE, mark-recapture estimate not possible, recapture period precluded due to incidental take limitations

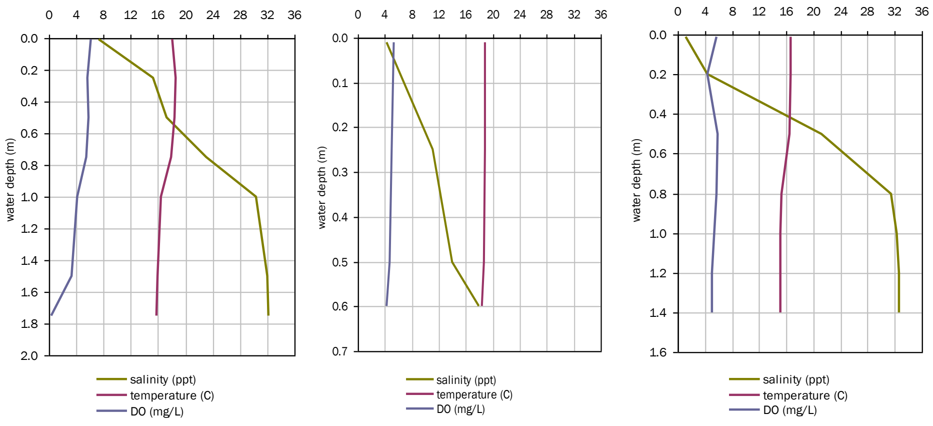
Both CPUE and abundance estimates have varied substantially between locations on any sampling date and between sampling dates. Part of the variability in steelhead abundance in the lagoon may be related to overall abundance of juvenile steelhead in the San Lorenzo River watershed as a result of differential spawning, incubation, emergence, and early rearing success. Variability in catch also results from movement of fish into and out of the lagoon in response to changing habitat conditions and life history timing.

While abundance of rearing juvenile steelhead in the lagoon at any particular time may be influenced by a number of factors, lagoon inflow and/or sandbar closure and associated water quality parameters likely play an important role. Water quality conditions at the time of steelhead population sampling provide an indication of what conditions may or may not be tolerable for steelhead in the lagoon.

Vertical profiles of temperature, DO and salinity measured in the lagoon on or about the dates of steelhead monitoring indicate highly variable conditions at locations where steelhead were captured. Steelhead juveniles were relatively abundant at the railroad bridge on July 6, 2004 with a catch rate of 24.5 steelhead per seine haul and an open lagoon. Temperature was relatively moderate at 18°C or less but DO was low, 6 mg/l or less, and salinity was high, about

8 ppt at the surface and increasing to 15 ppt at a depth of about 8 inches and about 30 ppt at a depth of 3 feet (Figure 2-12a).

Figure 2-12: Water Quality Parameters Measured in the San Lorenzo River Lagoon at Selected Locations and Dates



a). WQ Site 2 July 6, 2004 b). WQ Site 5 July 6, 2004 c). WQ Site 2 August 15,2005

Source: 2NDNATURE

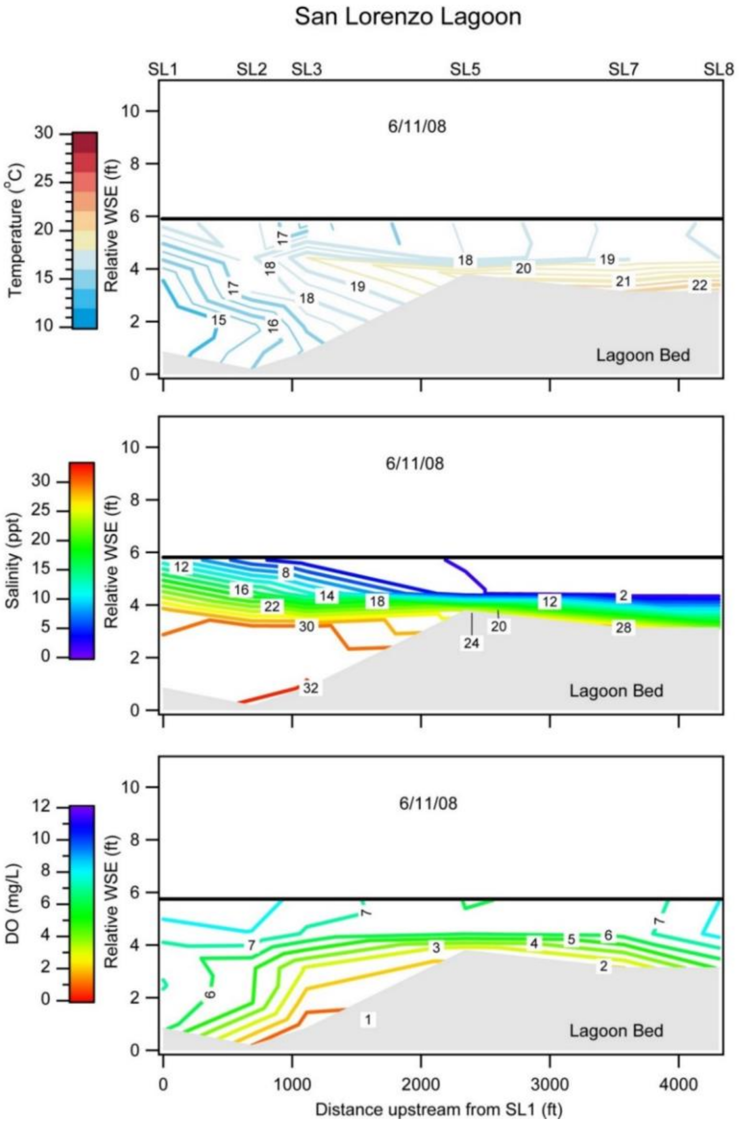
Steelhead were also abundant at Riverside Bridge (Site 5) on that date with a catch rate of 62 fish per haul. Temperature was comparable to the Railroad Bridge site and salinity was somewhat less, but DO was lower, declining from about 5 mg/l at the surface to about 4 mg/l at a depth of about 2 feet (Figure 2-12b).

On August 15, 2005, the lagoon was open and had not closed yet during the season. The catch rate for steelhead was the highest of any of the surveys at 179.5 per haul. These fish were at a location with relatively cool temperature but high salinity and low DO (Figure 2-12c). Salinity, while relatively fresh at the surface increased to 4 ppt at about 8 inches of depth and over 14 ppt at about 1.3 feet of depth. DO was less than 6 mg/l throughout the water column.

In early June 2008, steelhead population sampling was conducted in an open lagoon at a number of locations but juvenile steelhead were captured at only one location, near the railroad bridge in the lower part of the lagoon (Site SL2). Water quality monitoring at sites throughout the lagoon on June 11 revealed that this location had cooler temperature and higher DO than other locations, but also higher salinity (Figure 2-13).

These data indicate that depth is also a factor in suitability of habitat parameters for steelhead. Often, well-oxygenated, low-salinity water of suitable temperature can be found at a site, but only in the uppermost surface layer of water. At the surface, rearing steelhead are exposed to predation, particularly to the many fish-eating birds present in the lagoon. Suitable conditions of temperature, salinity, and oxygen at a depth of several feet would likely be much preferable to the same conditions at shallower depths. Cover in the form of large tree trunks or other structures may moderate the need for greater depth. This is complicated by the fact that the major prey items for rearing steelhead, such as gammarid amphipods, neomysis, and other invertebrate prey tend to be associated with the lagoon bed and are also sensitive to water quality parameters, particularly low DO.

Figure 2-13: Water Quality Parameter Values in the San Lorenzo River Lagoon Measured on June 11, 2008



Source: 2NDNATURE

As mentioned previously, lagoon inflow from the San Lorenzo River and sandbar closure are key variables influencing water quality conditions and suitability of the lagoon for rearing juvenile steelhead (2ndNature and HES 2016). Years with highest lagoon inflow (>20 cfs average August flow) had longer periods with an open lagoon (including micro-tidal) and, with the exception of 2011, supported the highest abundance of rearing juvenile steelhead observed (Table 2-17). The driest years (< 8 cfs average inflow in August) had the highest frequency of closed lagoon conditions and the lowest abundance of *O. mykiss*, including two years when none were detected after July. Years with intermediate levels of inflow varied in years had lagoon closure ranging from 11% to 67% (Table 2-17). The year with most extensive closure (67% in 2013) in this intermediate group also had the lowest CPUE for steelhead and the lowest growth rates while the year with least amount of closure (2016) had the highest *O. mykiss* abundance in the intermediate inflow group and relatively high growth rates. Extended lagoon closure in 2013, 2014, and 2015 was associated with high temperature conditions, temperature frequently in excess of lethal levels, and the apparent absence of steelhead in the lagoon by fall.

Table 2-17: Comparison of Lagoon Inflow and Sandbar Closure to Steelhead Population Variables

	Water Year precipitation (in)[1]	August Average daily San Lorenzo River discharge to Lagoon (cfs) [2]	Number of days sand bar closed May 15 to Oct. 31 (168 days in period)[3]	Number of days microtidal May 15 to Oct. 31 (168 days in period)[4]	Steelhead Fall CPUE	Steelhead Fall Population Estimate	Steelhead Average Growth Rate (mm/day)	Steelhead Average Growth Rate Range (mm/day)
2017	92.3	27.8	22 (13%)	10 (5.9%)	328.5	>3636	0.46	0.02-0.86
2011	62.2	25.8	11 (7%)	35 (21%)	2.5	138		0.5-0.7
2005	64.8	22.1	0 (0%)	56 (33%)	15.7	4000-5000		0.4-0.9
2010	48.9	12.4	60 (37%)	18 (11%)	28.2			
2016	48.6	9.7	19 (11.2%)	114 (67.5%)	7.8	1331	0.9	0.45-1.14
2013	36.2	9.5	114 (67%)	12 (7%)	4.7		0.34	0.27-0.41
2012	34.4	9	54 (32%)	25 (15%)	14.4	714	0.72	0.58-0.84
2018	29.0	8.7	102 (61%)	6 (3.6%)	6.3	704	0.39	0.26-0.49
2004	35.5	6.8	45 (27%)	20 (12%)	0.1			
2015	35.5	4.1	149 (88%)	N/A	0	0	N/A	N/A
2008	39.6	2.3	97(57%)	15 (9%)	0.1			
2009	36.5	2.1	87 (51%)	13 (8%)	0.5			
2014	24.5	1.9	151 (89%)	N/A	0	0	N/A	N/A

Source: 2ndNature 2019, HES 2019

N/A - not available, no monitoring performed, or limited data

[1] Precipitation data provided by the County of Santa Cruz from the Felton Diversion rain gage station.

[2] Hydrology data from USGS gage #11161000, San Lorenzo River at Santa Cruz.

[3] Sandbar closure is determined from visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

[4] Microtidal conditions occur when the sandbar is partially present, reducing surface water exchange to every few days and water circulation within the lagoon is limited. It is determined using visual observations and the derivative of YSI depth data (dz/dt), using parameters established in CLEAP.

There are exceptions to this pattern which also provide interesting insights. In 2018, closure was extensive (61%) and growth rates were relatively low but abundance in the fall was relatively high. Abundance was also relatively high in June of that year (third highest CPUE, Table 2-15) but dropped to lower levels later in the summer after lagoon closure, particularly in July when the lagoon was warmest. A number of *O. mykiss* moved out of the lagoon and upstream in the

San Lorenzo River after mid-June as documented by observations of PIT tagged fish at the Felton Diversion in July and August (HES 2019). Also, a group of large (260mm FL to 390mm FL) *O. mykiss* appeared in the catch in September but had not been seen earlier in the summer except for a few individuals in June. These fish may have recently entered the lagoon from the ocean as all had an external appearance characterized as adult/ocean and three of them had sea lice (possibly *Lepeophtheirus salmonis*) (HES 2019).

Fall abundance of *O. mykiss* was lower in 2011 than other high-inflow years and there was indication that many fish may have left the lagoon for the ocean during the extensive open lagoon period. Abundance in June 2011 was high and comprised a large number of larger fish and a high percentage of smolts (25%). *O. mykiss* with the external appearance of smolts were also present in October, a highly unexpected occurrence (HES 2012) as were a number of larger fish, several with sea lice indicating recent return from the ocean (several Chinook salmon were also captured in October).

Fall abundance estimates may be influenced by movement of large juvenile/small adult *O. mykiss* into the lagoon from the ocean in years when the lagoon has been open around the time of the fall survey (HES lagoon survey reports 2012-2019). This has been described above for 2018 and 2011. In all years from 2011 to 2019, except 2014 and 2015 when the lagoon was closed and no *O. mykiss* were captured, large *O. mykiss* of 250-400 mm length (10 to 16 inches) and the external appearance of ocean fish (very silver, deep body) have been captured in the lagoon in the fall. The presence of sea lice was observed on some of these fish in 2011, 2012, 2013, 2018, and 2019. The appearance of these fish in the lagoon was associated with the capture of Chinook salmon in 2011 and 2012, and pink salmon in 2019. The movement of large fish into the lagoon in the fall has also been indicated by a shift in the length frequency distribution with a group of larger *O. mykiss* appearing in the catch after a breach event (2012) or appearing in the fall survey but not present in August (2013, 2016, 2018). In addition, an *O. mykiss* tagged in Laguna Creek lagoon on September 20 was recorded at Felton on November 8. This fish was 159mm FL at the time of tagging. It would have left Laguna lagoon after it opened October 15 and entered the San Lorenzo lagoon, also mostly open after October 14. The reproductive status (juvenile, adult) of any of these individuals is not known.

In summary, observed abundance of *O. mykiss* in the lagoon has been highest in years with high rainfall and lagoon inflow and extended open sandbar conditions. Abundance has been very low in years of low rainfall and lagoon inflow with extended closed sandbar conditions. There is both direct and indirect evidence that juvenile or small adult *O. mykiss* enter the lagoon in the early fall (September) when the mouth is open after spending a short time in the ocean.

Steelhead will not necessarily perish under poor conditions in the lagoon but may move upstream to habitat in the lower San Lorenzo River where water quality conditions are more favorable. Lower food resources and rearing capacity in upstream areas may result in lower smolt production than potentially occurs in the lagoon under favorable conditions. Movement of *O. mykiss* from the lagoon to upstream areas has been documented by observations of PIT tagged fish at an instream antenna installed just downstream of the Felton Diversion Dam by the NOAA Southwest Fisheries Science Center. The antenna has been operational since October 2015 (Table 2-18).

In each of the three years when the antenna has been operational, fish tagged in the lagoon have migrated upstream beginning as soon as the same month they were tagged. Two of the fish tagged in June 2016 were observed at the Felton Diversion that same month and 6 more were observed at the Felton Diversion in July. The majority of observations of lagoon-tagged fish has been in November and December of the year in which they were tagged. This is suggestive of a potadromous or estuary migrating life history strategy. The portion of tagged fish observed at the Felton Diversion in the first season after tagging has ranged from 5% in 2018 to 22% in 2016. Other lagoon-tagged fish have first appeared at the Felton Diversion Dam during the typical winter spawning season (December through April) one to two years after being tagged, indicative of the typical steelhead anadromous life history (Table 2-18).

Table 2-18: Number of Lagoon-Tagged Steelhead Observed at the Felton Diversion by Tag Date and Date of First Appearance at the Felton Diversion

Date Initially Observed at Felton		Date Tagged									Total
		2016		2017				2018			
		Jun	Sep	Jun	Jul	Aug	Sep	Jun	Aug	Sep	
		Number Tagged									
		405	190	667	157	121	314	551	46	202	
2016	Jun	2									2
	Jul	6									6
	Aug	1									1
	Sep										0
	Oct	11									11
	Nov	59	29								88
	Dec	15	5								20
2017	Jan										0
	Feb		1								1
	Mar		1								1
	Apr		1								1
	May										0
	Jun										0
	Jul			3							3
	Aug			2	1						3
	Sep			1							1
	Oct										0
	Nov			40	13	8	13				74
	Dec					1					1
2018	Jan			8	1	1					10
	Feb						1				1
	Mar	3	1				1				5
	Apr			1							1
	May										0
	Jun										0
	Jul							12			12
	Aug							3			3
	Sep										0
	Oct										0
	Nov							4	1	8	13
	Dec							4		9	13
2019	Jan	1	2					1		2	6
	Feb		1	2	1			1		1	6
	Mar			2	1			2		1	6
	Apr			2			1			1	4
Total		98	41	61	17	10	16	27	1	22	4

Source: Felton Diversion tag recoveries provided by NOAA Southwest Fisheries Science Center

Lagoon inflow and sandbar closure also influences other aspects of the lagoon ecosystem, including the types and abundance of available forage resources for juvenile steelhead. Martin (1995) found that prey types and feeding levels vary in response to open or closed lagoon conditions in the Pescadero Creek Lagoon (San Mateo County). Although the sample sizes and sample dates are somewhat limited, Martin concluded that when the lagoon mouth was open and the estuary was open to tidal action, steelhead in both the upper and lower parts of the estuary fed heavily on euryhaline species, including amphipods (*Corophium* and *Eogammarus*), mysid shrimp (*Neomysis*), and isopods (*Gnorimosphaeroma*), when tidal inflows boosted their populations. After sandbar formation and the lagoon mouth closed, populations of marine and euryhaline invertebrate species declined and fish often shifted much of their diet to the rising populations of freshwater dependent species. However, based on observations of stomach fullness, steelhead appeared to feed more heavily while the lagoon was open to tidal action or immediately after closure. This was true for steelhead collected in both the upper and lower lagoon (Martin 1995). Martin concludes that steelhead find abundant food throughout the lagoon when it is open to full tidal mixing but that, after sandbar closure food appears to be most available at sites where there is freshwater, abundant pondweed, and where freshwater and euryhaline invertebrates are abundant. This is consistent with distribution of steelhead in the Navarro River Lagoon discussed previously (Cannata 1998). Steelhead forage organisms were surveyed in the San Lorenzo River Lagoon as part of the CLEAP study (2ndNature 2006) in 2004. During extended closure of the San Lorenzo River Lagoon during late summer, significant blooms of dinoflagellates were observed, and the zooplankton community was dominated by large numbers of very small copepod cells. Smaller size zooplankton are likely less suitable as a food source for rearing steelhead (2ndNature 2006).

In a survey of several Central California lagoon systems, Smith (1990) concluded that juvenile steelhead survival and growth was excellent when lagoons were open to full tidal mixing and when the closed lagoons were converted to freshwater. Growth was poor during long, stratified transition periods between sandbar closure and conversion of the lagoon to freshwater.

Growth rates of steelhead rearing in the San Lorenzo River Lagoon were measured based on recaptures of tagged fish during the CLEAP study in 2005 (Table 2-19). In spite of water quality parameter levels that, at certain times and locations, were often outside the range generally thought suitable for steelhead, juvenile steelhead maintained relatively good growth rates through the summer of 2005. Average growth rates were 0.4 to 0.9 mm per day in August, September, and October (2ndNature 2006). Growth rates of steelhead in the San Lorenzo River Lagoon were generally higher than those in Aptos, Soquel, and Laguna lagoons during the same period though not as high as in Scott Creek (2ndNature 2006). Growth rates were also measured by HES in 2012 through 2018. Growth rates were highest in 2012 and 2016. Both years had relatively high inflow (average August flow of 9 cfs in 2012 and 9.8 cfs in 2016, see Table 2-12) and were closed less than 50% of the time. The 2012 season had frequent open conditions with numerous breaches and short periods of closure (HES 2013). In 2016 the lagoon also underwent a pattern of filling and breaching throughout the summer (HES 2017) but the lagoon outlet formed a long channel to the west along the beach and breaches were relatively controlled with stage never dropping lower than 3 to 4 feet (National Geodetic Vertical Datum of 1929 (NGVD 29) and little, if any, tidal influx.

Table 2-19: Steelhead Growth Rates in the San Lorenzo River Lagoon

Year	N	Average June-Sept Growth (mm/day)	Range June-Sept Growth (mm/day)	September CPUE
2005			0.4-0.9	
2012	5	0.72	0.58-0.84	14.4
2013	2	0.34	0.27-0.41	4.7
2014	None captured			
2015	None captured			
2016	21	0.90	0.45-1.14	7.8
2017	40	0.46	0.02-0.86	328
2018	10	0.39	0.26-0.49	6.3

Source: data from 2NDNATURE 2006, Ellen Freund (NMFS), HES 2013, HES 2014a, HES 2015, HES 2016, HES 2017, HES 2018, and HES 2019)

Inflow was also high in 2017, with August average flow of 27.8 that kept the lagoon mostly open through the summer, but growth rates were lower than 2012 and 2016 (ANOVA single factor, Tukey HSD, α<0.01). Abundance of *O. mykiss* in the lagoon was unprecedented in 2017 (Table 2-16) and there may have been density dependent growth depression.

Growth rates in 2013 and 2018 were comparable to 2017 but lower than 2012 and 2016 (ANOVA single factor, Tukey HSD, α<0.01).[24] Inflows were similar to 2012 and 2016 (9.4 in 2013 and 8.7 in 2018) but the lagoon was mostly closed with only a few, short-duration breaches (HES 2014b, HES 2019, 2ndNature 2014, 2ndNature 2019). Growth rates were not measured in 2014 and 2015 since *O. mykiss* did not persist in the lagoon over the summer. Only a few fish were tagged in June and no fish were captured in the lagoon in the fall. Inflows were very low in both years with average August flow in the San Lorenzo River at the Tait Street Diversion of 1.9 cfs in 2014 and 4.2 cfs in 2015. The lagoon was closed most of the summer in both years.

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[24] The sample size was low in 2013 and may not have adequately represented the population as a whole.

Water temperature during surveys was very warm in both years (HES 2015, HES 2016). Surface DO levels had also declined intermittently to levels below 2 mg/l during the late-July and early-August period in 2014 (2ndNature in prep.).

To provide some perspective, Cannata (1998) reported average growth rate of 0.13 to 0.61 mm/day between June 1 and November 16, 1996 in the Navarro estuary compared to 0.40 to 0.90 in the San Lorenzo estuary in 2005. Growth rates in the San Lorenzo estuary in 2005 were also higher than those reported by Cannata for the Mattole River estuary (maximum of 0.40 mm/day) (Cannata 1998 citing Zedonis 1992).

In summary, *O. mykiss* growth rates in the San Lorenzo Lagoon can be high but are quite variable and appear to be related to patterns of lagoon inflow and sandbar closure. When inflow was low, as in 2014 and 2015, the lagoon is closed for extended periods and growth rates of *O. mykiss* are low. At higher inflow levels, as in 2012, 2013, 2016, and 2018, growth rates were high in years when the lagoon was mostly open during the summer with periods of brief closure (2012) or closed with frequent breaches but little tidal inflow (2016). Growth rates were low in years with extended lagoon closure (2013 and 2018). In 2017, when inflow was very high and the lagoon was open and tidal for most of the summer, growth rates were also low but this may have been a density dependent effect due to the unprecedented population levels that year.

Peak abundance estimates for steelhead rearing in the San Lorenzo River Lagoon were more than 3,636 in 2017 and 4,000 to 6,000 during late summer 2005. To provide some context: Cannata estimated approximately 9,000 steelhead rearing in the Navarro River estuary in 1997. The Navarro River estuary is significantly larger than the San Lorenzo River Lagoon. The lower three miles of the estuary channel is about 93 acres (Cannata 1998) while the San Lorenzo River Lagoon has a surface area of 34 acres when closed. The Navarro is also a larger watershed at 303 square miles compared to 136 square miles for the San Lorenzo. Jankovitz reported population estimates ranging from 914 to 7,300 for steelhead rearing in the 296-acre Pescadero Creek Lagoon complex (San Mateo County California) which has an 81 square mile watershed, during multiple sampling events in 2018 (Jankovitz and Diller 2019). That same year, population estimates in the San Lorenzo Lagoon ranged from 2378 in June to 704 in September. While steelhead abundance in any watershed may fluctuate widely from year to year, it appears that the San Lorenzo Lagoon at least has the potential to support a healthy number of rearing steelhead under the right conditions.

Overall conclusions relevant to conditions in the San Lorenzo Lagoon for rearing steelhead that can be drawn from these data and other results of the CLEAP study include the following:

- San Lorenzo Lagoon habitat has been highly altered and is missing components favorable to steelhead rearing such as fringing marsh vegetation, riparian canopy, and cover such as large fallen tree trunks. Unlike the Scott Creek and Laguna Creek Lagoons, which have transition zones between freshwater and saltwater characterized by emergent vegetation and gravel substrate, the San Lorenzo River Lagoon has little to no emergent vegetation in this zone and sand substrate.
- Eutrophication is advanced in the lagoon. Eutrophic conditions are created by excess availability of DIN, the limiting nutrient in CLEAP study lagoons. Compared to the other CLEAP study lagoons, the seasonal loading of DIN to San Lorenzo River Lagoon is high.
- Vertical water column stratification due to either salinity or temperature induced density differences accelerates depletion of oxygen in bottom waters. Lagoon closure and/or conversion to freshwater does not necessarily eliminate water column stratification since temperature induced stratification can still occur.
- The water quality in San Lorenzo Lagoon is typically poorer during reduced circulation conditions (micro tidal and/or closed). High solar exposure, elevated DIN inputs, and large areas of deep water result in persistent density stratification during reduced circulation regimes coincident with low DO levels and elevated chlorophyll levels. Immediately following initial lagoon closure bottom water temperature typically increases and DO, pH and ORP all decline.
- Observed abundance of *O. mykiss* in the lagoon has been highest in years with high rainfall and lagoon inflow and extended open sandbar conditions. Abundance has been very low in years of low rainfall and low lagoon inflow with extended closed sandbar conditions.
- A variable portion of the lagoon population of *O. mykiss* move from the lagoon to upstream areas beginning in the summer and peaking in November. This is suggestive of a potadromous or estuary migrating life history strategy. There are also indications that, under certain conditions, juvenile or small adult *O. mykiss* enter the lagoon in the early fall (September) after spending a short time in the ocean.
- *O. mykiss* growth rates in the San Lorenzo Lagoon can be high but are quite variable and appear to be related to patterns of lagoon inflow and sandbar closure.

These data suggest that the relationship between lagoon closure, inflow, and conditions for steelhead rearing may be quite complex and variable as are patterns of use by rearing juvenile *O. mykiss*. The following are implications for management actions:

- A minimum lagoon inflow of at least 8 cfs appears to promote habitat conditions conducive to steelhead rearing although peak abundance has occurred at higher levels of inflow.

- An open lagoon with tidal exchange and/or inflows of 20 cfs appears to provide optimum conditions for rearing steelhead.
- Habitat conditions deteriorate after 2-3 days of lagoon closure. If inflow and sandbar status are such that the lagoon enters fill and spill cycles with periods of 1-2 weeks, conditions will be very poor for steelhead rearing. There may be an exception if the sandbar elevation is perched and tidal exchange is limited as occurred in 2016.
- Opening the lagoon for flood control, if needed, should be conducted to avoid full drawdown of the lagoon and minimize the potential for tidal inflows by controlling the release of the lagoon to a predetermined level and ensuring immediate closure of the lagoon following drawdown.
- Installation of the culvert project to maintain the lagoon elevation below a level that results in flooding should be operated in a way to avoid early closure of the lagoon, ensure timely opening of the lagoon in the fall, and ensure an open lagoon whenever it would occur in the absence of the project.
- There is evidence of life history diversity in the San Lorenzo River involving movement of steelhead between the lagoon and the ocean that occurs outside the commonly accepted smolt seaward migration (March through May) and adult upstream migration windows (December through March or April). This life history diversity should be protected by allowing open lagoon conditions for migration when it would occur in the absence of management actions and when it does not lead to unfavorable water quality conditions in the lagoon.
- Movement of steelhead from the lagoon to upstream rearing areas in the middle and upper mainstem San Lorenzo may be an important life history feature for part of the population and should be protected.
- Greater knowledge of steelhead and coho life history patterns in the San Lorenzo system and their response to variable habitat conditions would improve species conservation.

2.4.3.2 Habitat Conditions Newell Creek

Newell Creek supports resident rainbow trout populations and steelhead and is within the critical habitat designation for steelhead. No coho have been observed in Newell Creek during annual surveys conducted by Santa Cruz County, the City of Santa Cruz, and others since at least 1994 (Don Alley personal communication to Chris Berry, 2020). Since Newell Creek is within the critical habitat designation for coho and since it has a relatively high intrinsic potential value[25] (NMFS 2012), the anadromous reach of Newell Creek is considered potential habitat for coho and is managed accordingly under the HCP.

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[25] IP values represent the historical potential of channel width, mean annual discharge and gradient to provide suitable habitats and support higher abundances of coho salmon (Agrawal et al. 2005).

Watershed/hydrology

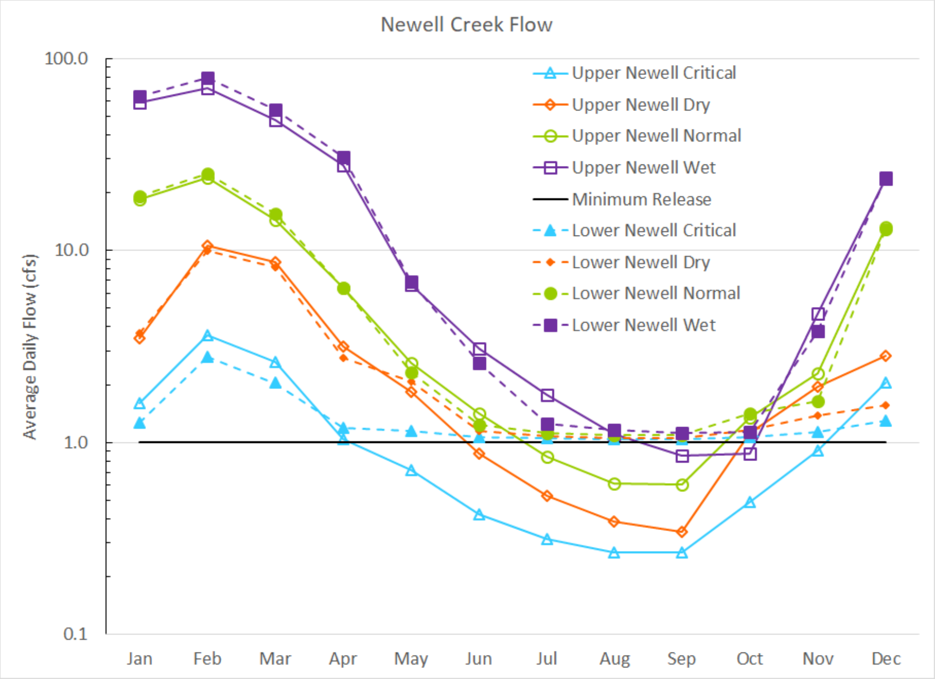
Newell Creek is a third order tributary to the San Lorenzo River, joining the San Lorenzo River at Ben Lomond. The City's Water Department maintains a 190-foot-high earthen dam (completed in 1960) on Newell Creek about 1.7 miles upstream from the San Lorenzo River confluence. The entire Newell Creek watershed is about 9.9 square miles and Loch Lomond Reservoir captures runoff from approximately 8.3 square miles (ENTRIX, Inc. 2004b). The reservoir capacity is 8,991 acre-feet (ENTRIX, Inc. 2004b). The watershed upstream of Newell Creek Dam is rural open space with no significant residential or commercial developments (ENTRIX, Inc. 2004b). The Loch Lomond Recreation Area (LLRA) owned by the City and operated by the City's Water Department occupies 425 acres adjacent to the reservoir. The LLRA is managed for water quality as well as recreational benefits. The City also owns the Newell Creek Watershed Lands, which comprise 2,880 acres adjacent to Loch Lomond Reservoir and the LLRA (ENTRIX, Inc. 2004b). Downstream of the reservoir, Newell Creek is bordered by residential development in the first 0.9 miles from its confluence with the San Lorenzo River and relatively undisturbed in the remaining 0.8 miles. See Figure 1-5: Newell Creek Watershed Map.

Above the reservoir, the highest monthly average flows occur in February and the lowest flows occur in September (Figure 2-13). Average February flow during the hydrologic record (1936-2015) ranges from 3.6 in critical dry years to 69.9 in wet years. In September, average flow has ranged from 0.3 cfs in critical years to 0.9 cfs in wet years (Confluence Model Output, Gary Fiske and Associates, Inc.).

Flows downstream of Loch Lomond Reservoir are influenced by reservoir inflow and storage conditions. Standard facility operations for Newell Creek include a year-round minimum release requirement of 1 cfs below Newell Creek Dam. During the fully appropriated season (as defined by the California Water Resources Control Board), there is a requirement that the greater of 1 cfs or the natural flow of Newell Creek must be released.

Hydrologic modeling indicates that the operation of the reservoir results in a slight reduction in average flows through the anadromous reach (compared to reservoir inflows) during the early part of the rearing period in critical and dry years, and in an augmentation of average flows during the summer rearing period due to the 1 cfs minimum release (Figure 2-13). Flow augmentation is highest (begins earlier) in critical years, and lowest in wet years. During critical dry years, the 1 cfs release requirement augments the natural flow throughout the rearing period and essentially doubles the median reservoir inflow from June through October.

Figure 2-14: Inflow to Loch Lomond Reservoir from Upper Newell Creek and Release to Lower Newell Creek for 1937-2015 Water Years



Source: Data from Gary Fiske and Associates, Inc.

During periods of high runoff, the reservoir fills and spillway releases result in downstream flows that are similar to reservoir inflow levels, in addition to a small contribution from the small watershed area downstream of the dam. City records for the period 1961 to 2008 indicate that the reservoir has spilled during 34 out of the 56 years (Table 2-20). In those years, the first spill occurred in December in 6 years, January in 12 years, February in 9 years, March in 3 years, and April in 1 year. No spill occurred in 22 of the 56 years of record. During the dry period from 1985 to 1994, there was no spill in 8 out of 10 years, including six consecutive years from 1987 through 1992.

Table 2-20: Record of Spill at Newell Creek Dam

Year	Spill	End of Spill	Second Spill	Second End of Spill
1961	No Spill			
1962	No Spill			
1963	4/24/1963	7/5/1963		
1964	No Spill			
1965	1/14/1965	5/19/1965		
1966	No Spill			
1967	1/30/1967	6/15/1967		
1968	3/24/1968	5/28/1968		
1969	1/20/1969	5/27/1969		
1970	1/25/1970	4/1/1970		
1971	No Spill			
1972	No Spill			
1973	2/13/1973	4/10/1973		
1974	3/17/1974	5/11/1974		
1975	No Spill			
1976	No Spill			
1977	No Spill			
1978	2/9/1978	5/9/1978		
1979	3/27/1979	4/15/1979		
1980	1/18/1980	4/18/1980		
1981	No Spill			
1982	1/19/1982	5/17/1982	12/23/1982	
1983		5/25/1983	12/31/1983	
1984		2/10/1984		
1985	No Spill			
1986	2/17/1986	5/11/1986		
1987	No Spill			
1988	No Spill			
1989	No Spill			
1990	No Spill			
1991	No Spill			
1992	No Spill			
1993	2/19/1993	3/2/1993		

Table 2-20: Record of Spill at Newell Creek Dam (continued)

1994	No Spill			
1995	1/28/1995	6/3/1995		
1996	2/15/1996	3/18/1996	12/31/1996	
1997		3/2/1997		
1998	2/3/1998	4/30/1998	6/1/1998	6/10/1998
1999	2/6/1999	6/9/1999		
2000	2/10/2000	4/23/2000		
2001	No Spill			
2002	1/9/2002	5/19/2002	12/22/2002	
2003		3/10/2003	3/16/2003	5/22/2003
2004	1/4/2004	4/28/2004		
2005	1/8/2005	6/1/2005	12/22/2005	
2006	12/22/2005	5/28/2006		
2007	No Spill			
2008	2/4/2008	4/14/2008		
2009	3/16/2009	4/23/2009	5/3/2009	5/9/2009
2010	1/20/2010	4/28/2010		
2011	1/6/2011	6/19/2011		
2012	3/17/2012	5/6/2012	12/23/2012	
2013		4/12/2013		
2014	No Spill			
2015	No Spill			
2016	3/13/2016	4/6/2016	4/22/2016	4/30/2016
2017	1/4/2017	5/11/2017	5/16/2017	5/24/2017
2018	4/1/2018	5/12/2018		
2019	2/3/2019	6/29/2019		
2020	No Spill			
2021	No Spill			

Instream Habitat

There are three distinct reaches of Newell Creek downstream of Loch Lomond Reservoir, each with different aquatic habitat characteristics and fish populations (HES 2007). A lower reach, approximately 0.85 miles in length, consists of relatively low gradient, gravel/cobble stream channel that is accessible to anadromous fish and supports steelhead/rainbow trout and Pacific lamprey. A middle reach, of approximately 0.59 miles in length, is dominated by bedrock substrate that occurs in frequent shelves or steps of a few inches to a few feet in height. This middle reach supports *O. mykiss*, primarily in the lower part of the reach, which may be either anadromous or resident. The bedrock formations in this reach present numerous potential migration obstacles that may present barriers to migration in certain flow ranges. (HES 2014b, Hagar et al. 2017b). The uppermost reach begins about 1.45 mile upstream from the San Lorenzo River and continues for about 0.3 miles to the low water crossing at the spillway pool. This upper reach is relatively low gradient with predominantly gravel/cobble substrate but less suitable habitat for *O. mykiss*, which includes less extensive and shallower pools, less instream cover, and less potential spawning area than the lowermost reach. There is a very sparse population of *O. mykiss* in the uppermost reach, likely a resident (non-anadromous) population, with apparently low levels of production and/or low reproductive success (HES 2007).

Construction of Newell Creek Dam has had a major influence on instream habitat conditions downstream of the Dam. Residential development along the banks in the lower reach has also had detrimental effects. The dam has prevented the downstream movement of sediment and fallen trees into the lower reach. All gravel and cobble sediments that form habitat for spawning and rearing and all input of large wood objects (LWO) derived from fallen trees derives from inputs downstream of the dam. Disruption of sediment input to the upper and bedrock reaches has resulted in incision of the bed, diminishment of gravel and cobble substrate preferred by steelhead and coho, loss of recruitment of habitat forming LWO, and possibly led to greater exposure of bedrock outcroppings which limit pool depth and present migration obstacles (Holley 2010). Continued trapping of sediment behind the dam will result in continued acceleration of channel incision. The lower reach has also been severely impacted by channel incision but is more resilient due to the lower-gradient, alluvial nature of the channel and has the most intact salmonid habitat and the greatest potential for improvement (Holley 2010). In addition to channel incision, bank stabilization to protect riparian development has prevented lateral migration from recruiting LWO and cobble/gravel substrate, and incision has disconnected the channel from whatever floodplain may have existed before anthropogenic alterations (Holley 2010).

Migration Barriers

A bedrock chute downstream of Newell Creek Dam is judged to be a complete barrier to coho and a temporal barrier and practical limit of anadromy for steelhead (Hagar et al. 2017b). This bedrock chute is approximately 1 mile upstream from the confluence of Newell Creek with the San Lorenzo River and approximately 0.7 miles downstream from Newell Creek Dam (Figure 1-

5). The chute occurs in a longer section of stream dominated by bedrock substrate and having numerous bedrock shelves beginning about 0.85 miles upstream of the San Lorenzo River confluence. These bedrock shelves also limit the ability of steelhead or coho to migrate upstream and may make upstream areas inaccessible at certain flow levels (HES 2014b). During reconnaissance surveys in May 2006 at a flow of about 5 cfs, minimum thalweg depth on many of these shelves was only 0.1 to 0.2 feet (Hagar, personal observation).

A hydraulic survey conducted by HES at the bedrock chute concluded that an adult steelhead would not be able to leap the chute and that its ability to swim over it would be limited by shallow depth of flow and high velocity, but may be possible for a fish in peak condition at a flow in the range of about 200 to 325 cfs (HES 2014b). The survey also concluded that it is unlikely that adult coho would be able to pass this obstacle at any flow (HES 2014b). This is consistent with the previous assessment by Don Alley (Alley et al. 2004). On April 11, 2017, a team of biologists representing NOAA Fisheries, CDFW, and the City conducted a site visit at the bedrock chute. The team confirmed the HES assessment although there were different opinions about the level of flow that might be needed for passage (Hagar et al. 2017b).

In addition to the bedrock chute, other potential barriers have been identified during a high-resolution bathymetry survey in the inundation zone of Loch Lomond Reservoir (Hagar et al. 2017b). The survey, completed in 2008 with a 2-foot contour interval, shows two steep sections of 18% and 30% gradient located 1,700 feet and 2,000 feet upstream of the fish release (the point where flow is released to Newell Creek from Loch Lomond Reservoir). These locations seem to present even more severe obstructions than the bedrock chute 0.7 miles downstream of the dam. The lower feature has a 6-foot elevation gain over a 32-foot distance; the upper has an 8-foot elevation gain over a 26-foot distance. Separately or in combination, these features would have severely limited and likely precluded passage of steelhead and coho to upstream habitat (Hagar et al. 2017b).

Habitat conditions between the bedrock chute and the dam are not that good for steelhead. During habitat surveys conducted in 2007, it was found that the bedrock dominated reach (where the bedrock chute is located) and the upstream reach below Newell Creek Dam had markedly less instream cover and less potential spawning area than did the lower reach (HES 2007). The uppermost reach had the least suitable habitat for *O. mykiss*, including less extensive and shallower pools, less instream cover, and less potential spawning area. Abundance of *O. mykiss* in both visual surveys during the habitat assessment and in electrofishing surveys dropped off markedly in the upper half of the bedrock reach (beginning upstream of the bedrock feature) and in the uppermost reach (HES 2007).

Riffles in the lower 0.85 miles of Newell Creek may also impede passage of adult salmonids under low flow conditions. During reconnaissance surveys in May 2006 at a flow of about 5 cfs, the minimum thalweg depth in these riffles was generally 0.5 to 0.7 feet; although shallower riffles were only 0.4 to 0.5 feet deep (HES field notes May 11, 2006). These depth conditions would likely not meet migration criteria for adult steelhead or coho, nor would they be met during periods when the reservoir is not spilling and stream flow is at the 1 cfs minimum fishery release. HES conducted an assessment of the relationship between flow in Newell Creek and hydraulic conditions (depth and velocity) at four critical riffles in Newell Creek downstream of Rancho Rio Bridge (HES 2014b). This survey indicated that minimum passage criteria for steelhead and coho adults (a depth of at least 0.6 feet across 25% of the channel width and a continuous section of 10% of the channel width) would be met when flow in Newell Creek reaches 12.3 to 21.7 cfs or more. Minimum passage conditions for steelhead or coho smolts (a depth of at least 0.3 feet across 25% of the channel width) would occur at flows of 2.8 to 6.2 cfs or more.

Based on these assessments, the potential for migration passage for adult salmonids appears to be very limited at times when Newell Creek is not spilling. The hydraulic model results suggest that passage for smolts may also be limited at times when the reservoir is not spilling (see Chapter 5 for details on lifestage timing and analysis of passage thresholds and duration of suitable passage conditions). Historical operations have resulted in some reduction in spill frequency early in the migration season (December) in critical and dry years but have preserved migration opportunities later in the migration season and in normal and wet years (Figure 2-14). Future operations that maintain Loch Lomond Reservoir at higher levels would be beneficial due to higher potential for spill.

Spawning Habitat

Potential spawning area is most extensive in the lowermost reach of the three sub-reaches of Newell Creek downstream of Loch Lomond Reservoir (HES 2007). Substrate is dominated by gravel and small cobble in the lower and upper sub-reaches and by bedrock in the middle sub-reach. Gravel or cobble were the dominant substrate in 71% of habitat units in the lower sub-reach and 90% of habitats in the upper sub-reach. Bedrock dominated in 59% of habitat units in the middle sub-reach and gravel was dominant in 28%. Sand was found as a dominant substrate in 12% of habitat units in the lower sub-reach but not a dominant in any habitat units in either the middle sub-reach or the upper sub-reach (HES 2007). This may be due to either more disturbance from adjacent residential development, lower gradient, or both. In riffle type habitat units, gravel or cobble was the dominant substrate in both the lower and upper sub-reaches while bedrock (in the form of bedrock sheets) dominated in the middle sub-reach. There were, on average, 24 square feet of potential spawning area per 100 feet of stream surveyed in the lower reach compared to only 13 square feet in the bedrock reach and 10 square feet in the upper reach.

Pool tail and spawning gravel embeddedness[26] ratings were low to moderate in all surveyed sub-reaches of Newell Creek in August 2007 (HES 2007). Only a few pool tails had embeddedness ratings of more than 30% while 50% to 65% had embeddedness of 15% or less. Most spawning areas had embeddedness ratings of less than 30% and 70% of spawning areas in the lower and middle sub-reaches had embeddedness of less than 15%. These values are indicative of relatively low amounts of fine sediments in the substrate of Newell Creek relative to other Central California Coastal streams.

HES conducted an assessment of the relationship between stream flow and the amount of potential spawning habitat in Newell Creek during a brief period when the reservoir spilled during late February and early March 2008 and during more extensive spill in 2010 (HES 2014b). For steelhead, the spawning suitability index increases at relatively high rates up to 10 to 14 cfs; is high (at least 80% of the peak value) across a very broad range of flow between 13 and 38 cfs with a peak at about 24 cfs; and declines gradually at higher flows (HES 2014b). The spawning suitability index for coho tends to peak at slightly lower flows than for steelhead with the highest suitability at flows between 8 and 35 cfs (80% of the peak value) and a peak at 20 cfs.

An adult steelhead was seen at one of the spawning study sites in late February 2008 immediately after the only spill event of the winter. Numerous YOY steelhead were also seen at this location during a reconnaissance survey in May 2006. These observations suggest that steelhead are still supported in Newell Creek and that they may be dependent on spill events to persist. Spill events have been relatively common since the drought of the late-1980s and early 1990s, occurring in 18 of the 22 years from 1995 to 2016 (Table 2-13). The relatively small storage capacity of Loch Lomond Reservoir and the City’s operational strategy of keeping the reservoir as full as possible have assured relatively frequent and extensive spill and resulted in a hydrograph in Lower Newell Creek that is very similar to the unimpaired hydrograph for Upper Newell Creek (Figure 2-13). This has led to maintenance of suitable spawning and migration

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[26] Embeddedness ratings are an indication of the degree to which the surface layer of larger substrate particles (cobble or large gravel) are embedded in fine sediments. Incubation and emergence success are influenced by accumulation of fine sediments (generally less than 3.3 mm) in the substrate. Embryo survival for steelhead decreases when the percentage of substrate particles less than 6.4mm reaches 25% to 30% and is extremely low when fines are 60% or more. Emergence of steelhead and coho fry is generally high when fine sediments are less than 5% of substrate volume but drops sharply with fine sediment volume of 15% or more (Bjornn and Reiser 1991). While embeddedness ratings are not a direct measure of percentage of fine sediment in the substrate, they are related.

habitat conditions for steelhead and coho even without explicit bypass flow requirements for these life stages.

Rearing Habitat

In surveys of Santa Cruz County streams during 1981, Harvey & Stanley Associates (1982) characterized rearing habitat quality for steelhead in Newell Creek as good at a site downstream of Glen Arbor Road (lower sub-reach) and below average to fair at sites further upstream, near the border of the middle and upper sub-reaches. Rearing densities of *O. mykiss* were good compared to other streams sampled that year. According to City records, the reservoir did not spill in 1981 (Table 2-13).

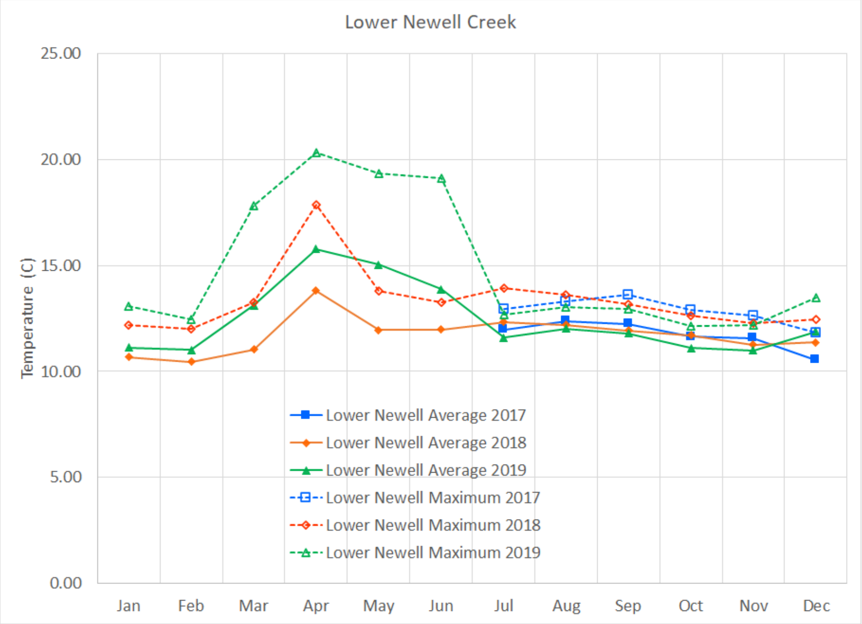
Conditions for rearing steelhead were found to be relatively good in a habitat survey conducted in August 2007 for the reach of Newell Creek between Loch Lomond Reservoir and the San Lorenzo River confluence (HES 2007). Conditions were better in the lowermost sub-reach than in the middle or upper sub-reaches. Pools made up approximately 40% of the lower and middle sub-reaches, by length, but only about 28% of the upper reach (HES 2007). The upper sub-reach was dominated by step runs, glides, and runs. The middle sub-reach had a higher proportion of riffles (primarily bedrock sheets) than the upper and lower sub-reaches. Pools were longer in the lower sub-reach than the other two reaches, averaging 85 feet in length compared to 59 feet in the middle reach and 57 feet in the upper reach. Pools were more frequent in the middle reach than the other two reaches, averaging 35 pools per mile as compared to 25 and 26 pools per mile. Pools tended to be deepest in the lower sub-reach and shallowest in the upper sub-reach. Most pools in the lower and middle sub-reaches had maximum depths over 2 feet, while only 38% of pools in the upper sub-reach had pools that deep (HES 2007).

Shelter complexity, though mostly at low to moderate levels in all sub-reaches, tended to be higher in the lower sub-reach. Over 80% of pools in the lower sub-reach had shelter influencing at least 20% of the habitat area, while only 29% and 13% of pools in the middle and upper sub-reaches had shelter that extensive. The most extensive and frequently encountered cover type was the space around and between cobble and boulder substrate. Terrestrial vegetation hanging over the stream margin and undercut banks were important cover types in the lower sub-reach while bedrock ledge and undercut banks were important in the middle sub-reach. Nearly 80% of the cover in the upper sub-reach was provided by substrate and surface turbulence. Canopy coverage was relatively dense throughout all three reaches, averaging around 80%.

The 1 cfs minimum fishery release downstream of Loch Lomond Reservoir is often higher than reservoir inflow levels during the dry season (Figure 2-14), particularly during drier years and during the latter part of the dry season (July through October). These operational measures are likely to improve dry season rearing conditions most of the time, but in particular, during the most critical periods - late summer and very dry years. The instream flow requirement also results in flow augmentation in the mainstem San Lorenzo River downstream of Newell Creek, although the proportional increase is much smaller.

The temperature of water released from Loch Lomond Reservoir is generally in the range of 10° to 14°C under normal storage levels and water temperature measured downstream of the reservoir release is generally in that range except during spill when it can be warmer (Figure 2-15). During periods when the reservoir spills, water from the surface of the reservoir is released down the spillway and mixes with the fish release downstream of the dam. Since spill is from the reservoir surface, it can be warmer than the fish release during the warmer parts of the year. However, the majority of spill occurs during or after precipitation events in the winter when Loch Lomond temperature is cool. The period when temperature effects are most likely is during the spring and early summer (May through July) when the lake surface is warming and there is still a potential for spill, at least in wetter years when storage is high.

Figure 2-15: Lower Newell Creek Temperature Monitoring Results



Source: City of Santa Cruz Water Department Monitoring Data

Temperature monitoring data collected by the City indicate that surface water temperatures in Loch Lomond Reservoir closest to the spillway can reach levels that are potentially harmful to steelhead and coho (Figure 2-16). Sub-optimal temperatures (21°C or greater) have occurred 98% of the time in July, 85% of the time in June, 19% of the time in May, and only 1% of the time in April. Surface temperatures in the City monitoring data have never been recorded above 18.3°C in March. Potentially lethal levels (25°C or higher) have also been recorded in June and July, although the frequency of such occurrence is low in June (less than 1% of readings).[27] Frequency of reservoir surface temperature of 25°C or higher in July has been observed 11% of the time. These data may slightly underestimate the frequency of temperature in the unsuitable range since it is generally recorded mid-morning while peak temperature usually occurs in the mid to late afternoon.

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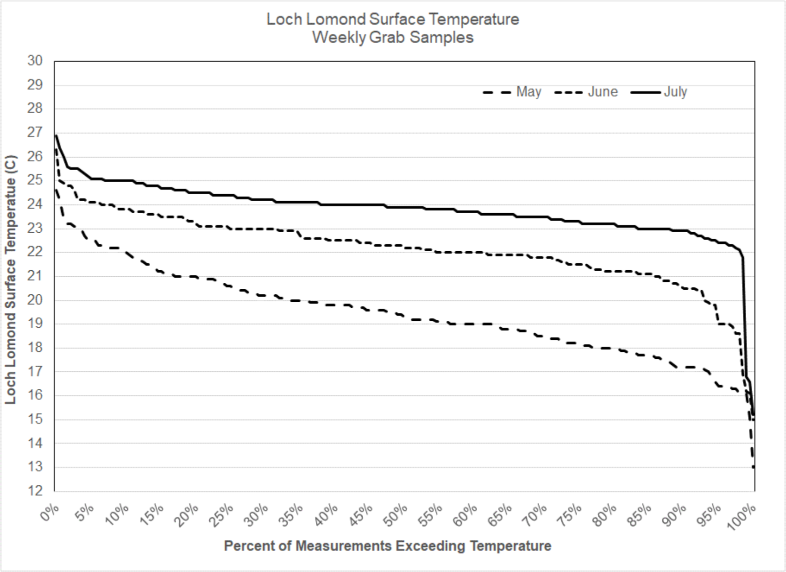
[27] Data are in the form of surface grab samples measured once per week, usually mid-morning, collected since 1987.

Figure 2-16**:** Loch Lomond Surface Temperature Measured by Weekly Grab Sample from 1987 to 2020



The effect of warm reservoir spills is moderated by the frequency, volume, and timing of spill. There is possible cooling at night (although potentially offset by additional warming during the day) as water flows down the spillway, and mixing with the cooler water from the fish release below the dam.

Limited temperature data available in Newell Creek downstream of the dam suggests that the effect of the spill on water temperature below the dam can be substantial but appears not to exceed suitable levels for rearing steelhead or coho. During 2019, the reservoir was spilling for most of the period from early February through late June. Maximum water temperature recorded below the dam[28] in April was 20.3°C when the reservoir was spilling at approximately 5 cfs or less (Figure 2-15). The average daily temperature below the dam, however, was never higher than 18.1°C in April. The reservoir was spilling at no more than 2 cfs in June 2019 and maximum recorded water temperature downstream reached 19.1°C. Average daily temperatures

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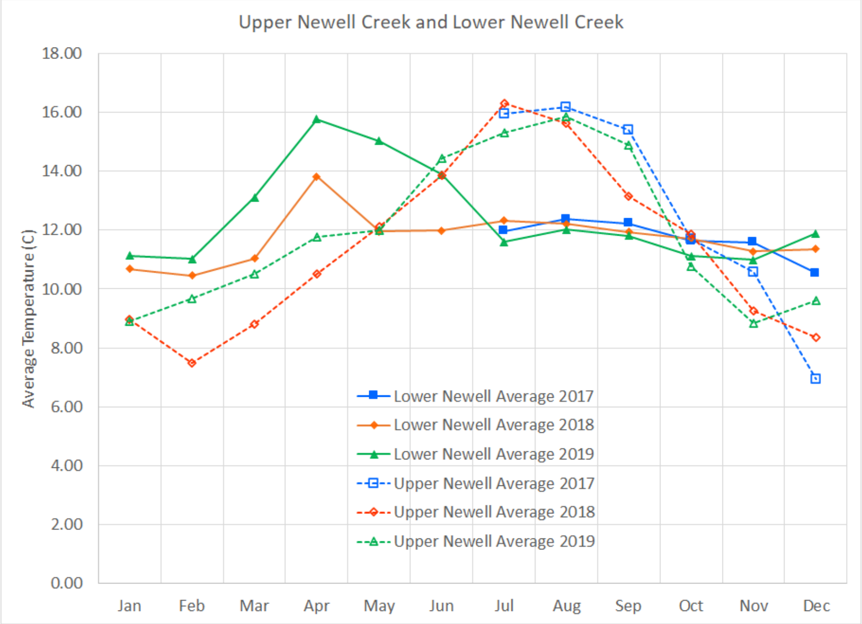
[28] Temperature, reflecting both the fish release and reservoir spill, is continuously recorded by the City at the stream gage downstream of the dam at a 15-minute recording interval. Data has been collected since July 2017.

were below 17°C during June and declined to less than 12°C by the time spill ceased near the end of the month.

Due to the presence of the reservoir, temperature in Lower Newell Creek below the dam is warmer than Upper Newell Creek during winter and spring and cooler in the summer by up to 4°C on average (Figure 2-17). Warmer water in the spring can enhance salmonid growth rates if food resources are sufficient. The cooling influence in summer can extend downstream as far as the San Lorenzo River (City of Santa Cruz monitoring data, HES 2014b). Although the cooling influence in summer may depress growth rates this effect would be strongest closest to the dam. Spot measurements of water temperature during a habitat survey on August 7 and 8, 2007 ranged from 14°C to 16°C in the lower reach, 12°C to 13°C in the middle reach, and 13°C (in the upper reach (HES 2007). Temperature increases downstream due to atmospheric warming bring temperature closer to an optimum range, particularly for juvenile coho, which prefer slightly cooler temperature than steelhead.

Figure 2-17: Comparison of Upper and Lower Newell Creek Temperature Monitoring Results

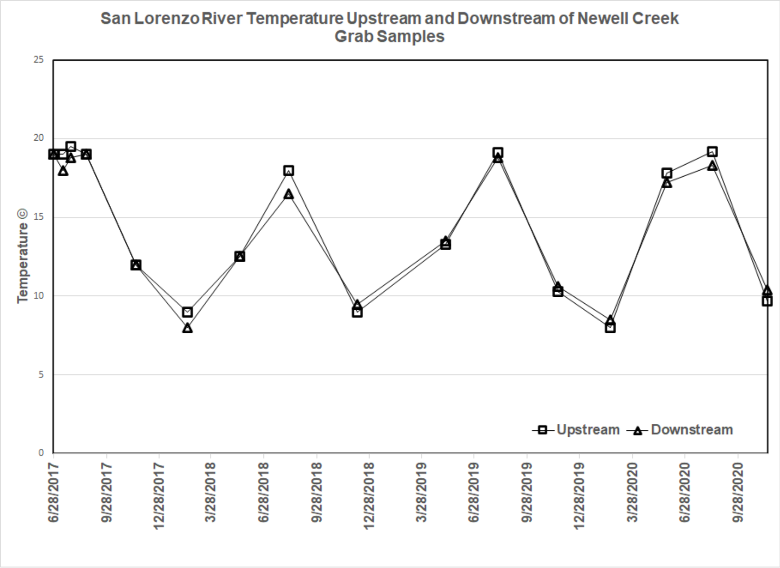


Source: City of Santa Cruz Water Department Monitoring Data

Release of water from the reservoir is likely to influence temperature conditions in the San Lorenzo River downstream of the Newell Creek confluence. There is a limited amount of temperature data for the San Lorenzo River at the Newell Creek confluence (Figure 2-18). These data indicate that water temperature in the San Lorenzo River approaches 20°C during peak summer warming and that Newell Creek appears to have a slight cooling influence during the summer (1°C or less) and a very slight warming influence in winter. The only datapoint potentially influenced by spill is May 9, 2019. Streamgage and reservoir elevation data indicate that the reservoir was spilling at a low volume (1 cfs or less) and temperature data records for Newell Creek below the dam show a value of 14 to 14.1°C bracketing the time temperatures were recorded in the San Lorenzo River. This is consistent with the observation of 13.3°C upstream of the Newell/San Lorenzo confluence and 13.5°C downstream of the confluence.

Warmer temperatures in April and May may actually be beneficial for rearing steelhead (and coho if present) as long as the temperature is still within the suitable range. Salmonids grow faster at warmer temperatures, within the suitable range, with adequate food supply. Increased spill in June may also be beneficial as long as it does not result in temperature above the suitable level.

Figure 2-18: San Lorenzo River Temperature Upstream and Downstream of Newell Creek, 2017-2020



2.4.3.3 Habitat Conditions Mountain Charlie Gulch/Zayante Creek

Mountain Charlie Gulch supports resident rainbow trout populations and steelhead and potentially supports coho should they become re-established in the San Lorenzo River watershed. Coho have not previously been reported in Mountain Charlie Creek, although there has not been extensive sampling there either.

Watershed/hydrology

The City owns approximately 1.4 square miles in the watershed tributary to Zayante Creek and lower Mountain Charlie Gulch.

Mountain Charlie Gulch is a first order stream tributary to Zayante Creek. It drains a watershed of approximately 2.6 square miles and has approximately 4 miles of perennial stream (CDFW 1997b). Mountain Charlie Gulch has no stream gaging records. The watershed is mainly forested with some rural residential development and roads. Zayante Creek is a fourth order tributary to the San Lorenzo River. Flow in Zayante Creek was measured by the USGS (station # 11160300) from 1958 to 1992 at a stream gage located 3 miles upstream of the San Lorenzo River confluence. During the period of record, the median daily flow ranged from 8.6 cfs in February to 0.5 cfs in September (ENTRIX, Inc. 2004b). Winter flow is highly variable with daily average flows in January, for example, ranging between 0.4 and 1690 cfs. The bankfull discharge, approximated by the 1.5 to 2-year flood, is in the range of 430 to 825 cfs. The lowest flows occur in August and September. Average August and September flow for all years of record is 0.8 cfs, ranging from mean flows of 1.4 cfs in wet years to 0.2 cfs in critically dry years. See Figure 1-6: Zayante Watershed map.

Instream Habitat

Migration Barriers

Debris accumulations in Mountain Charlie Creek, exacerbated by the continuing effects of past logging activities, have resulted in transient migration passage impediments (CDFW 1997b). The City Water Department implemented a steelhead passage improvement project and modified several of these in 2002. A potential complete barrier to steelhead migration is located in Mountain Charlie Creek approximately 2.7 miles upstream of the confluence with Zayante Creek. This natural barrier consists of a series of bedrock ledges (ENTRIX, Inc. 2004a).

The anadromous reach of Zayante Creek extends upstream from the confluence with the San Lorenzo River past the confluence with Mountain Charlie Gulch, possibly to beyond Fern Ridge Road (Brian Spence personal communication to Chris Berry, 2005). There are bedrock ledges in Zayante Creek that have historically formed potential migration obstacles. A ladder was installed at one of the worst of these, near Quail Hollow, and some work to improve another was completed near Zayante Store (Chris Berry, personal communication to Jeff Hagar 2006). Another ledge, located just upstream from the Bean Creek confluence, is associated with the Mount Hermon flashboard dam. This location also has a seasonal fish ladder providing passage for juveniles in the summer when the dam is up and passage for adults in the winter when the dam is down.

Spawning Habitat

Spawning habitat is probably somewhat degraded by high levels of fine sediment. HES (2004) found embeddedness of both pool tails and other potential spawning areas typically ranged from 5% to 45%, although a few pool tails had embeddedness ratings of 60% or more (these were just downstream of a landslide in the lower part of the study reach). Embeddedness values were significantly less than those recorded by CDFW (1997b), however the Zayante Creek watershed has highly erodible soils and the stream bed is composed of a high proportion of fine-grained sediment (ENTRIX, Inc. 2004a). Fine particles (less than 4 mm) made up between 11 and 28 percent of the Zayante Creek streambed and larger substrate (particle sizes greater than 16mm) were 25% to 46% embedded in fine sediment (ENTRIX, Inc. 2004b, SH&G 2001b). The highest densities of steelhead redds in San Lorenzo River watershed are often observed in Zayante Creek (Jon Jankovitz, CDFW, personal communication to Jeff Hagar, 2019).

Rearing Habitat

Rearing habitat in Mountain Charlie Gulch consists primarily of run type habitat, limited amounts of instream cover, and high levels of fine sediments but with relatively dense canopy (ENTRIX, Inc. 2004b). CDFW characterized Mountain Charlie Gulch as an entrenched meandering riffle/pool channel at low gradient and with a high width/depth ratio and predominantly cobble substrate (CDFW 1997b). In surveys of Mountain Charlie Gulch adjacent to City managed lands during 2004, HES found cool temperatures and good canopy characteristics (HES 2005a). During the August surveys, early morning stream temperature was 13°C to 13.5°C. Maximum air temperature reached 27°C during the survey but stream temperature did not exceed 16°C. Temperature conditions are consistent with the moderating influence of the extensive canopy coverage and may also be influenced by topographic shading (HES 2005a). HES found that habitat types in Mountain Charlie Gulch were relatively evenly distributed between riffle, flatwater (run and glide), and pool types (HES 2005a) and that pools in general provided good depth for rearing steelhead with plunge pools and lateral scour pools formed by bedrock having the greatest maximum depths (in the 3.1 foot to 4 foot depth range). The habitat type proportions are somewhat different from those measured by CDFW in 1997, possibly since the CDFW survey extended another 8,857 feet upstream from the endpoint of this survey. HES confirmed relatively high amounts of fine sediment although embeddedness values were significantly less than those recorded by CDFW in 1997. HES also found limited amounts of instream cover in Mountain Charlie Gulch but good canopy characteristics. Canopy coverage ranged from 5% to 90% and averaged 71%. Aquatic productivity can be inhibited under conditions of continuous closed canopy, and the ideal condition is a moderately dense canopy (55%-85%) with occasional small openings. The surveyed reach of Mountain Charlie Gulch provides nearly ideal conditions of canopy coverage with over 80% of individual habitat units having canopy coverage between 55% and 85% and 97% of units with coverage between 50% and 90% (HES 2005a).

Habitat surveys conducted in Zayante Creek indicated that pools account for the majority of existing instream habitat, with flatwater and riffles making up relatively small proportions, particularly in upper reaches of Zayante Creek and Mountain Charlie Gulch (H.T. Harvey and Associates 2003a).

2.5 Covered Species

2.5.1 Steelhead (*Oncorhynchus mykiss*)

Listing Status and Distribution

Steelhead (*Oncorhynchus mykiss*) inhabiting the drainages within the Plan Area are part of the Central California Coast DPS. CCC Steelhead are listed as threatened under the federal ESA (NMFS 2006). The Central California Coast DPS consists entirely of winter-run steelhead and extends from the Russian River south to Aptos Creek in the southern end of Santa Cruz County. The Plan Area is located in the southern range of the Central California Coast DPS (Busby et al. 1996). Streams in the Plan Area are included in the critical habitat designation for CCC Steelhead (NMFS 2005a). Recovery of the Central California Coast Steelhead DPS is addressed in the *Coastal Multispecies Final Recovery Plan: California Coastal Chinook Salmon ESU, Northern California Steelhead DPS and Central California Coast Steelhead DPS,* released in October 2016 (NMFS 2016).

Life History and Habitat Requirements

Steelhead life history is quite diverse and adaptive, providing the necessary flexibility to survive varied environmental conditions naturally occurring throughout their range and within their natal watershed. In general, steelhead grow and mature in the ocean and spawn in freshwater. In central California, adult steelhead enter coastal streams during the wet season in association with increased runoff. The majority of steelhead enter freshwater from December through March or April, and spawn relatively soon after entering freshwater. Spawning occurs in the tail-end of pools or runs where the female buries her eggs in pockets (or redds) excavated in a gravel-cobble substrate (Shapovalov and Taft 1954). The length of time it takes eggs to hatch is dependent on water temperature with hatching in about 30 days at 10.6°C and longer at cooler temperatures. The embryos remain within the gravel until they are fully developed and ready to begin feeding. Upon emergence from the gravel, the young steelhead (or fry) typically disperse to the stream margins in close vicinity of the redd. As the fish grow, they move to areas with more suitable feeding and hiding conditions (e.g., heads of pools, pocket water, etc.). Juvenile steelhead can spend from 1 to 3 years in freshwater before beginning physiological processes that prepare them for life in seawater (termed smoltification). Steelhead begin the process of smoltification, most commonly at a size of 150 to 200 mm (6 to 8 inches) and migrate downstream to the ocean as early as the fall, but most commonly in the spring (March-May). Steelhead may spend from 1 to 2 years in the ocean before reaching maturity and returning to their natal stream to spawn (Shapovalov and Taft 1954).

Steelhead are unusual among the Pacific salmonids in that they are capable of spawning more than once, as they do not necessarily die after spawning. After spawning, some of these fish, called kelts, return to the ocean after holding for a short period of time in freshwater (Barnhart 1986). Steelhead are also unusual in that they have several life history strategies. Young steelhead produced from common parents have the capability of following distinctly different forms. Some may remain in freshwater even when the ocean is readily available. These fish can reach sexual maturity and spawn without ever entering the ocean. Furthermore, the progeny of these "resident" spawning fish can produce young that assume an anadromous life history and leave the freshwater environs as juveniles to grow and mature in the ocean before returning to spawn. This life history variability provides greater potential for population persistence, especially in areas with episodic periods of prolonged drought that can prevent fish from entering or leaving the stream for several generations (Titus et al. *In draft*).

Population Status and Limiting Factors

This section describes what is known about the abundance of steelhead populations and factors limiting those populations in each of the watershed areas covered by the HCP, including the North Coast Unit and the San Lorenzo River Unit. Abundance information is presented for each individual stream in each unit to the extent it is known.

North Coast

Steelhead populations in the North Coast streams are relatively small due to the short lengths of anadromous habitat. There are two primary sources of information relating to abundance of steelhead and coho in the North Coast Streams. The first is a synoptic survey of Santa Cruz County streams in the fall of 1981 by Harvey & Stanley Associates, Inc. (1982). The second is recent abundance estimates completed by the City since 2006. These are described below.

The Harvey & Stanley study measured the abundance of smolt sized steelhead (3 inches or larger, standard length[29]) in a number of Santa Cruz County streams using 2-pass electrofishing at several sites in each stream during the fall of 1981. In Liddell Creek, a total of eight sites were sampled, one in the main fork below the confluence of the East and West Branch, two in the West Branch, three in the East Branch below the Middle Branch confluence, and two in the East Branch upstream of the Middle Branch. Rearing density of steelhead was highest in the Lower West Branch (10 smolt-sized fish per 100 feet) and the Main Branch (6 smolt-sized fish per 100 feet). Rearing density was relatively low in the East Branch, ranging from 1 to 5 smolt-sized fish per 100 feet. Overall, abundance estimates for Liddell Creek fell in the moderate to low end of the range for this study, lower than both Laguna and Majors Creek (Table 2-14).

In Laguna Creek, a total of four sites were sampled in the Harvey & Stanley study, all of them upstream of what is now believed to be the limit of anadromy. Abundance of these resident *O. mykiss* populations may be quite different than for the anadromous population in the lower part of the creek. Abundance estimates for Laguna Creek fell in the moderate to low end of the range for this study (Table 2-14).

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[29] In the Harvey & Stanley study fish equal to, or larger than, 3 inches were considered smolt-sized since it was believed that they would reach sufficient size for smolting by the following spring.

Table 2-21: Abundance Estimates for Smolt-sized Steelhead/Rainbow Trout (>75 mm Standard Length, ~85 mm Fork Length) in Santa Cruz County Streams

Stream	Average Density (# per 100 feet of stream)	Maximum Density (# per 100 feet of stream)
San Vicente	40.9	200.0
San Lorenzo River	29.8	97.0
Zayante	22.0	46.0
Browns	16.5	27.0
Corralitos	16.1	60.0
Valencia	15.0	17.0
Baldwin	13.8	25.0
Newell	13.0	18.0
Shingle Mill Gulch	12.7	14.0
Bear	12.0	19.0
Fall	12.0	17.0
Soquel West Fork	11.3	17.0
Boulder	10.5	20.0
Mill (San Lorenzo)	10.5	16.0
Aptos	9.6	24.0
Bean	9.5	22.0
Majors	9.4	22.0
Jamison	8.0	8.0
Hester	7.0	7.0
Laguna	7.0	13.0
Bates	6.0	6.0
Liddell	6.0	10.0
Pescadero	6.0	7.0
Ramsey	6.0	6.0
Soquel East Fork	6.0	13.0
Kings	5.0	10.0
Liddell West Fork	5.0	10.0
Moore's Gulch	5.0	5.0
Gamecock	4.0	4.0
Hinkley	3.0	3.0

Stream	**Average Density (# per 100 feet of stream)**	**Maximum Density (# per 100 feet of stream)**
Liddell East Fork	3.0	5.0
Lockhart Gulch	3.0	3.0
Soquel	3.0	6.0
Carbonera	1.7	3.0

Source: Summarized from Harvey & Stanley 1982

A total of six sites were sampled in the Harvey & Stanley study in Majors Creek, but only two of them were within the anadromous section. Abundance in the anadromous reach was relatively low with no steelhead observed at the site downstream of Highway 1 and 8 per hundred feet of stream at a site near the upper limit of anadromy which is about 0.7 miles upstream of the mouth.

Since 2006, the City has developed abundance estimates for the anadromous reaches of Liddell, Laguna, and Majors Creeks based on annual fall snorkel surveys (Berry et al. 2019). Abundance of YOY steelhead has averaged 12.5 per 100 feet in Laguna Creek, 9.4 in Majors Creek, and 7.5 in Liddell Creek from 2006 to 2016 (Figure 2-19).[30] Similarly abundance of 1+ steelhead averaged 6.6 per 100 feet in Laguna Creek, 4.8 in Liddell Creek, and 3.8 in Majors Creek. Mean age 2+ steelhead abundance was highest in Liddell Creek at 2.3 per 100 feet and was 1.7 per 100 feet in both Laguna and Majors Creeks.

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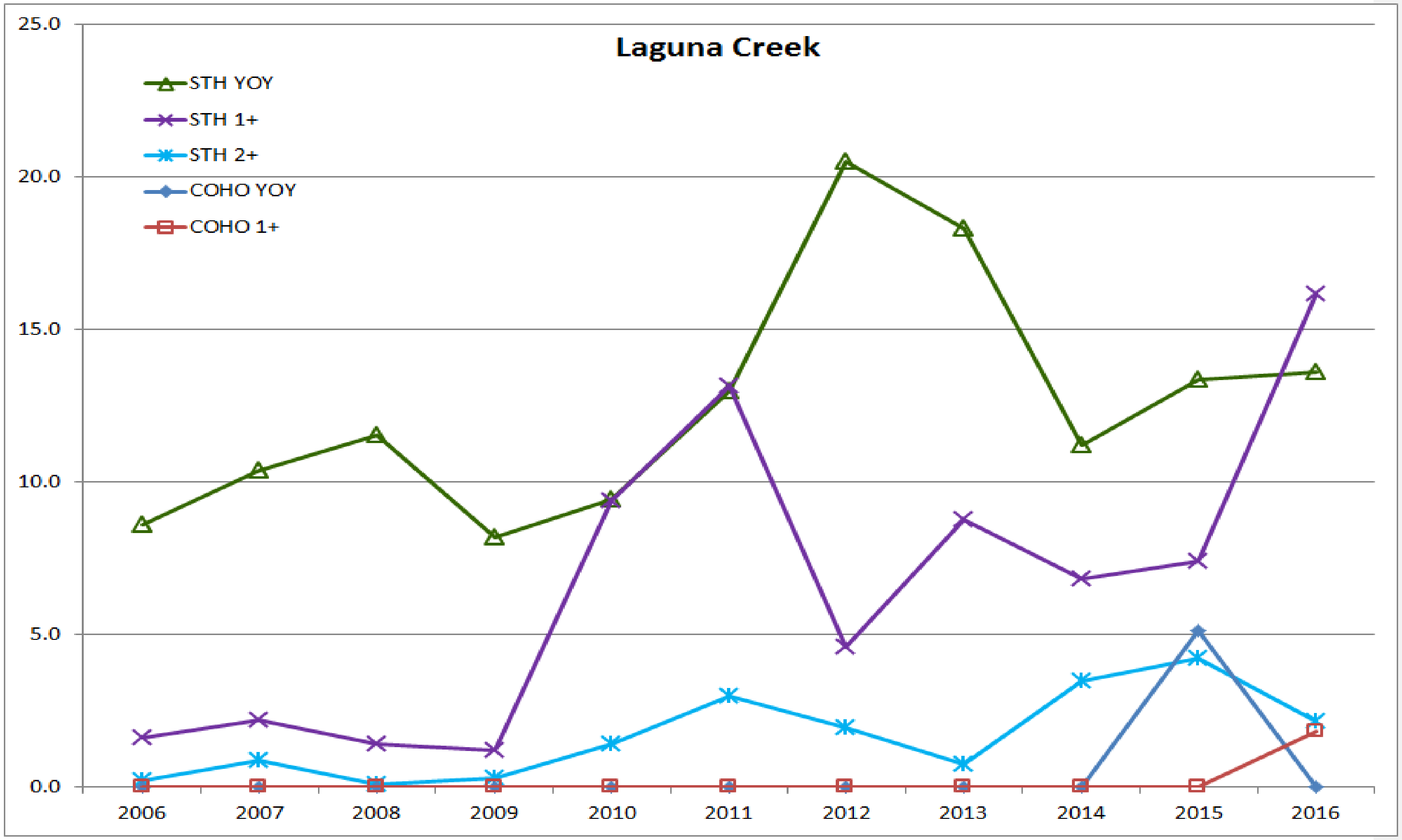
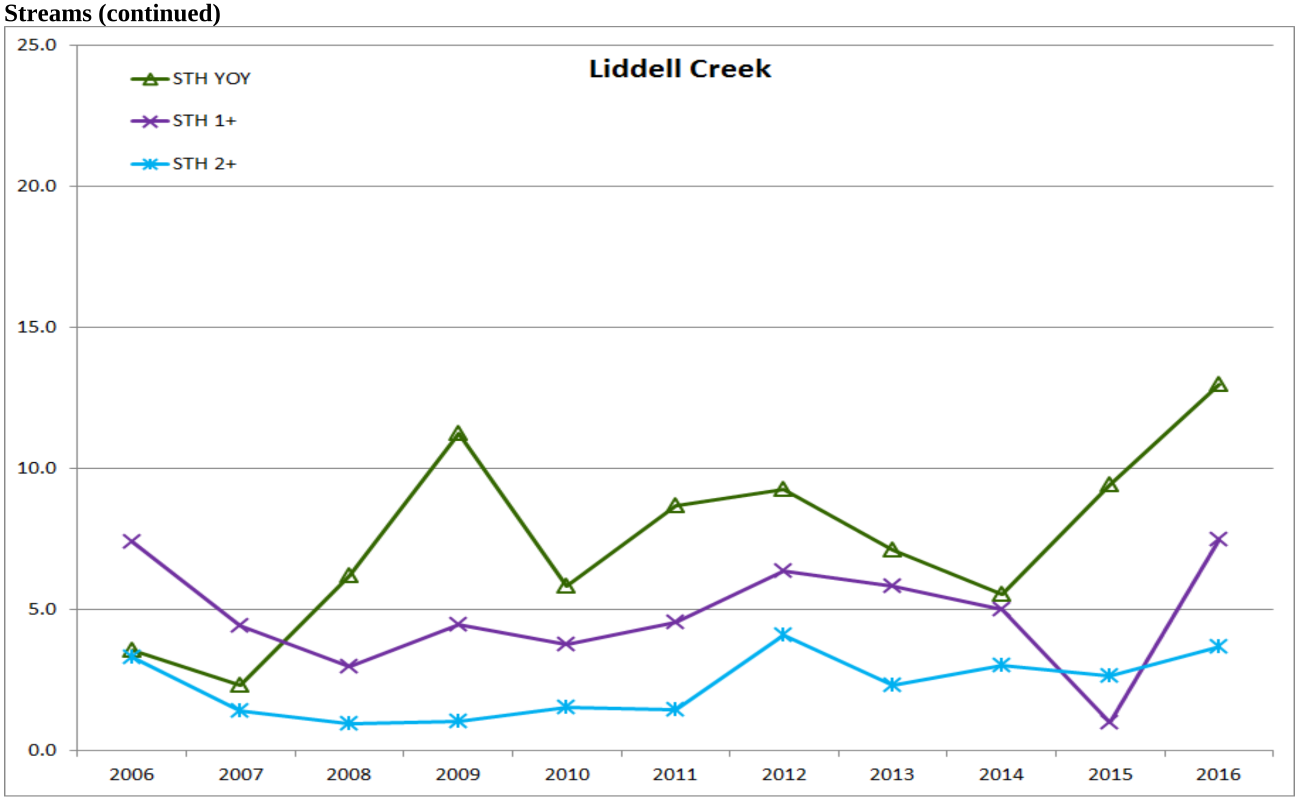
[30] More recent electrofishing data collected in 2009 indicate that these numbers could actually be somewhat higher, possibly by a factor of two (HES 2011b).

Figure 2-19: Abundance Estimates (number per 100 feet) for Steelhead/Rainbow Trout and Coho in Fall Snorkel Surveys of North Coast Streams



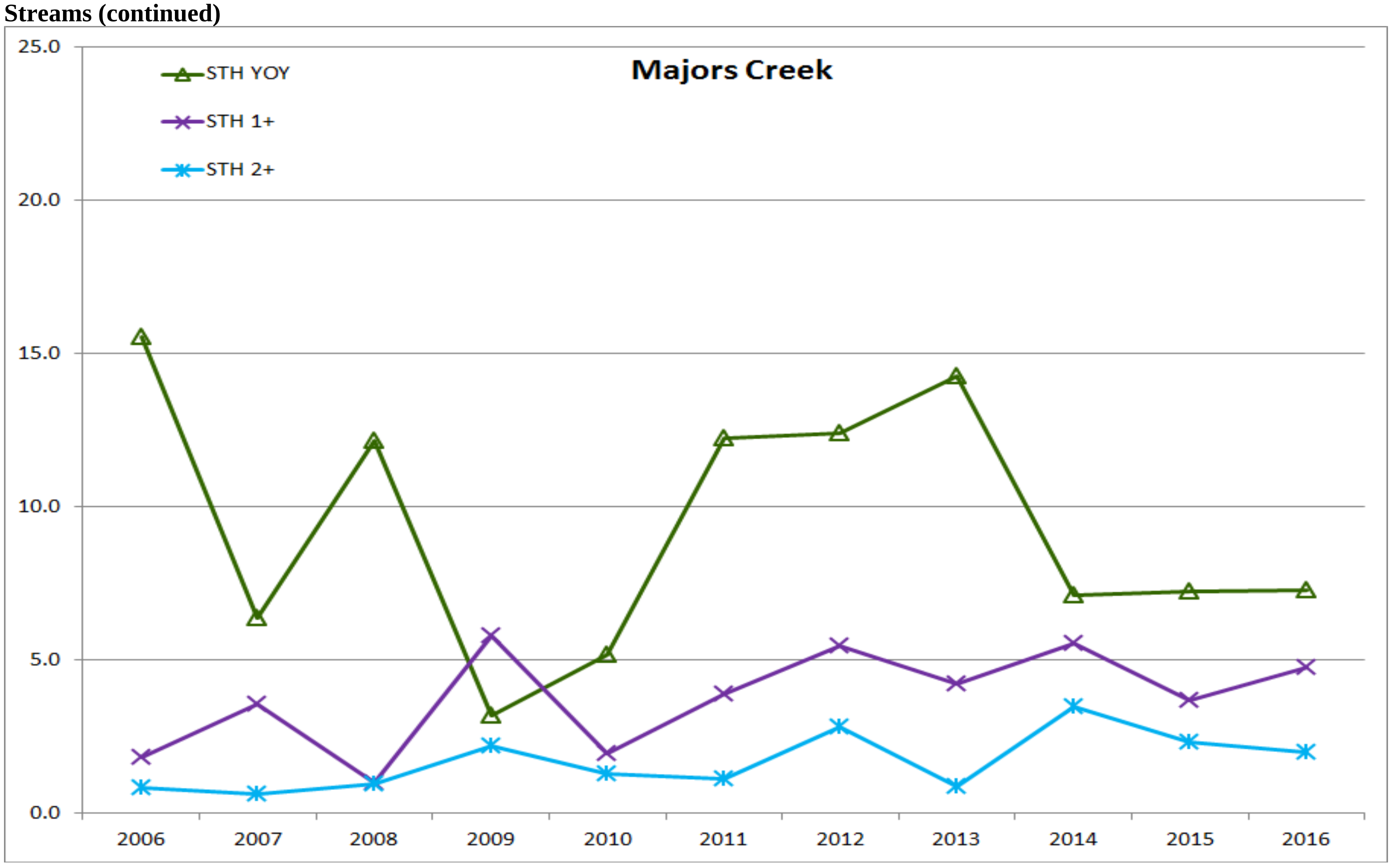
Source: City of Santa Cruz unpublished monitoring data

Figure 2-19: Abundance Estimates (number per 100 feet) for Steelhead/Rainbow Trout in Fall Snorkel Surveys of North Coast Streams (continued)



Source: City of Santa Cruz unpublished monitoring data

Figure 2-19: Abundance Estimates (number per 100 feet) for Steelhead/Rainbow Trout in Fall Snorkel Surveys of North Coast Streams (continued)



Source: City of Santa Cruz unpublished monitoring data

Abundance of both 1+ and 2+ steelhead shows an increase in Laguna Creek over the monitoring period (linear regression F-test, significance at 0.01). Increased abundance over time was also observed for YOY steelhead in Liddell Creek (linear regression F-test, significance at 0.03) and age 2+ steelhead in Majors Creek (linear regression F-test, significance at 0.04). It should be noted however that the efficiency of snorkel counts appears to have increased over the monitoring period based on calibration with electrofishing data (HES 2017). Nevertheless, this effect would likely be similar for all streams so the increase in abundance in Laguna Creek stands out. Combined abundance of age 1+ and 2+ steelhead is comparable to that observed in the early 1980s as reported by Harvey and Stanley (1982) (Table 2-21).

While adult population sizes have not been assessed in these streams, some context can be developed based on other information sources. Shapovalov and Taft (1954) marked juvenile steelhead on their downstream migration from Waddell Creek and estimated overall survival from returns of these marked fish in the adult steelhead spawning run. Returns ranged from 1.7% to 6% and averaged 3% for the five years evaluated. These estimates may be conservative since: (1) a number of downstream migrants actually remained in downstream reaches without migrating to sea for an additional season and would have experienced additional mortality before going to sea; (2) there was likely some loss of adults in the ocean due to fishing;[31] and (3) not all returning adults were checked for marks (some spawned downstream of the trapping station and some by-passed the trapping station during high flow conditions). However, the estimate is consistent with a more recent study in Scott Creek (Bond 2006). Bond estimated survival rates of downstream migrating steelhead in Scott Creek to be 3.3% and survival of estuary-reared juvenile steelhead to be 8.3 percent for the in 2003 cohort.

Using the City density estimates of smolt-sized steelhead in the fall, length of the anadromous reaches, pool proportions, and a 3% return rate for downstream migrating smolts, an estimate of adult returns from stream rearing fish is quite small with an average estimate of 4 adults returning to Liddell and Majors and 12 returning to Laguna Creek (Table 2-22). Even if stream densities were 3 to 4 times higher, these would still be very small populations. In contrast, the estimated Laguna Creek potential return of 69 adult steelhead from lagoon reared fish is substantially higher than the estimated total return of stream reared fish and more than an order of magnitude higher than Liddell and Majors Creeks. This is a result of the larger number of smolts produced and a higher survival rate of lagoon reared fish related to greater size at ocean entry.

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[31] At the time of the S&T studies in the 1950s there was an active recreational fishery in northern Monterey Bay.

Table 2-22: Steelhead Production Estimates in North Coast Streams

	Anadromous Reach Length (miles)	Percent Pools by length[1]	Density of Smolt-size Stream Steelhead (# per 100 feet) [1]	Population Estimate for Stream Smolts	Fall Lagoon Population Estimate for Smolts[2]	Adult Returns of Stream Smolts	Adult Returns of Lagoon Reared Smolts	Total Adult Return
Liddell	1.16	0.33	7.2	146		4		4
Laguna	1.43	0.63	8.3	395	828	12	69	81
Majors	0.7	0.72	5.5	146		4		4

[1] City of Santa Cruz snorkeling data.
[2] Based on fall 2014 abundance (HES 2015).

Suitable rearing habitat exists in the coastal streams, however the extent of this habitat is limited by the presence of natural barriers to upstream passage (ENTRIX, Inc.2004). The portion of these creeks accessible to steelhead and coho ranges from 0.6 miles in Majors Creek to 1.4 miles in Laguna Creek. Access is also indicated as a limiting factor in the West Branch of Liddell Creek due to culverts at road crossings (Harvey & Stanley Associates, Inc. 1982).

Sedimentation is also high in these streams, particularly in Liddell Creek, and may be the primary limiting factor in the Liddell Creek watershed (Environmental Science Associates 2001, ENTRIX, Inc. 2004b, Hagar 2005). Sedimentation was also observed to be a problem in the non-anadromous reaches of Majors Creek (ENTRIX, Inc. 2002) although this could further constrain the suitability of spawning and rearing habitats in the anadromous reach if the sand migrates downstream (ENTRIX, Inc. 2004b). Sedimentation affects the amount of spawning habitat (embedding gravels), the amount of rearing habitat (infilling pools), and production of salmonid food.

Harvey & Stanley Associates, Inc. (1982) suggest that rearing habitat is the most limiting factor for Santa Cruz County streams. They list several factors as key for rearing habitat, including:

- adequate flows for pool formation and to provide feeding stations,
- hiding cover (i.e. undercut banks, surface turbulence, boulders, overhanging vegetation, etc.),
- aquatic and terrestrial food, and
- suitable summer water temperatures.

The Harvey & Stanley report indicates that it is not necessarily the low late summer/fall flows in these streams that limits density of smolt-sized fish but the amount of adequate cover (pool development, undercut banks, and unembedded cobble). The importance of streamflow appears to be in spring when these fish show a large increase in size (Harvey & Stanley Associates, Inc. 1982). Limiting factors specifically indicated in the Harvey & Stanley study include pool depth, cover, substrate, and flow in Liddell Creek; flow, cover, pool depth, and substrate as most limiting in Laguna Creek; and flow as the major limiting factor for the anadromous reach of Majors Creek. Harvey & Stanley (1982) also rated spawning habitat as poor to fair in Majors Creek and rearing habitat as none (downstream of Highway 1) to below average and fair upstream of Highway 1 below "the falls".

ENTRIX, Inc. (2004b) concluded that flow can constrain suitable habitat during the dry summer and fall rearing seasons however suitable rearing conditions exist under current conditions. High canopy cover in the canyon-portions of the anadromous reaches maintain suitable water temperatures and instream cover is typically not a problem in these canyons (ENTRIX, Inc. 2004b).

Lagoon rearing may be critical to sustaining populations in these small streams with limited anadromous habitat. Of the three north coast streams with City diversions, only Laguna Creek has a relatively intact and functional lagoon. The lack of a functional lagoon may be a significant limiting factor in Majors and Liddell Creeks.

San Lorenzo River Watershed Unit

Available analyses suggest that steelhead have declined in the Central California Coast DPS and in the San Lorenzo River from historic levels. Alley et al. (2004) provide the following synopsis of steelhead population status in the San Lorenzo River:

> Over the last several years, a considerable amount of attention has been paid to salmonid populations and habitat conditions on the San Lorenzo River due to historical accounts that suggest a rapid decline in fish numbers since the 1960s. The California Department of Fish and [Wildlife] (CDF[W]) estimated that 20,000 adult steelhead were present in the San Lorenzo River prior to 1965 (Johansen, 1975). In the mid-1960s, CDFW estimated that 19,000 adult steelhead occurred in the San Lorenzo River. Estimates by the NMFS, made in 1996, put the number of adults spawning in the San Lorenzo River at 500.
>
> Unfortunately, estimates of historic adult steelhead numbers were based on conjecture and lack supportable scientific data. Most of the estimates were based on creel census data, which are inadequate to obtain accurate estimates of adult numbers and are more reflective of the extensive planting program in the San Lorenzo River rather than natural production. Scientifically supportable juvenile population and density estimates did not occur on the San Lorenzo until 1981 when Dr. Jerry Smith, with assistance from Donald

> Alley, conducted habitat surveys and sampling site density estimates on steelhead-bearing streams throughout Santa Cruz County (Smith 1982). Comprehensive habitat condition and population estimates were continued in 1994 by D.W. ALLEY and Associates and have been monitored every year since (Alley 1994-2001). These data suggest fairly stable steelhead populations between 1981 to present with year-to-year variations dependent upon sedimentation, streamflow, and habitat conditions in the River.

The San Lorenzo River Lagoon has the potential to produce a large number of steelhead smolts. In 2005, NMFS estimated that there were 4,000-6,000 smolts rearing in the lagoon over the summer months (2ND Nature 2006). In spring 2017, there were an estimated 3600 steelhead juveniles in the lagoon and monthly estimates of catch per unit effort doubled to tripled through September (HES 2018). These likely represent the maximum rearing capacity of the lagoon under present conditions. Using Bond's estimate of 8.3% return rates for estuary-reared steelhead, this would potentially result in a maximum return of approximately 400 adult steelhead from the lagoon in addition to those from production in the mainstem and tributaries.[32]

The primary factors limiting salmonid production in the San Lorenzo River watershed are related to excessive accumulation of fine sediments in rearing and spawning habitat, reductions in streamflow during critical life history phases, impediments to adult passage, and inhospitable water temperature conditions (Alley et al. 2004, Ricker and Butler 1979). Accumulation of fine sediments in the stream bed has degraded fisheries habitat by infiltrating gravel and cobble substrate and reducing water depth, particularly in pools. Mobilization and delivery of fine sediment from upland sources to the streambed has been accelerated beyond natural processes by timber harvesting and residential and associated development, including roads. Increased sedimentation may impair spawning success due to suffocation of embryos, failure of emergence, or excessive bed mobilization. The accumulation of fine sediments may also impair production of organisms used for food by rearing juveniles and thereby reduce rearing success or retard growth rates. Excessive accumulation of fine sediment can also reduce cover for rearing juveniles by filling the spaces around larger cobbles, boulders, and woody debris or under banks. Increased turbidity - which is often related to increased delivery of sediment to a given watercourse – can impair feeding success (as salmonids are visual feeders) and impair respiration (by clogging gills).

Ricker and Butler (1979) concluded that excessive sedimentation is widespread in the streams of the San Lorenzo Watershed and that sedimentation is the major cause of the fishery decline in the San Lorenzo Watershed. Observations of insect production in streams of the San Lorenzo Watershed show

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[32] To put this estimate in context, estimates of adult steelhead returns to the San Lorenzo River summarized from various sources by D.W. Alley & Associates (2005) range from around 300 to 3000 during discreet periods between the mid-1930s and 2004 when estimates were made.

biomass to be 75% to 90% lower in silted reaches of Bean, Zayante, and Carbonera Creeks as compared to the Upper San Lorenzo River. Ricker and Butler (1979) cite CDFW surveys on the main river showing that the percentage of stream bottom classified as silt measured from 8% in 1966 to 65% in 1972 and the amount of gravel present dropped from 20% to 2%.

Streamflow reduction is related to extraction of both surface and groundwater throughout the watershed. Rearing conditions affected by low stream flows during the dry season (May to October) are often a limiting factor in Central Coast streams. Density of rearing YOY steelhead has been shown to be positively correlated with various measures of stream flow in different parts of the San Lorenzo River basin and particularly in the mainstem below Boulder Creek (Alley et al. 2004). In some cases, low stream flows may further impede adult passage in the San Lorenzo River at critical locations related to either natural or anthropogenic features.

Ricker and Butler (1979) estimate that total stream diversions at the time of their study result in a 40% reduction in summer rearing habitat in lower Boulder Creek and a 20% reduction in summer rearing habitat in the middle portion of the river, lower Bear Creek, lower Fall Creek, and lower Zayante Creek. These reductions represented a 10% decrease in overall summer rearing habitat for the Watershed during normal years and a 20% reduction in rearing habitat during dry years attributable to stream diversions (Ricker and Butler 1979).

In critically dry years, populations can be limited by constraints on outmigration as well.
High water temperatures in the middle and lower San Lorenzo River (downstream from Boulder Creek) may limit overall production by restricting rearing juveniles to limited fastwater habitat. However, warmer temperatures may also result in faster and more robust growth (with abundant food resources), which may be a significant consideration for this part of the mainstem since it produces a substantial proportion of the watershed’s smolt-sized juveniles. Degradation of lagoon habitat through filling, maintenance as a FCC, nutrient enrichment, and reduced freshwater inflows may also limit production of smolts.

The Harvey & Stanley Associates, Inc. (1982) study found the average density of smolt-sized steelhead in Newell Creek at 13.0 per 100 feet was in the upper third of all streams sampled (Table 2-21). Rearing densities of smolt-sized fish in Newell Creek averaged about 18.3 per 100 feet of stream during population surveys conducted from 1994 to 2001 and 10.6 per 100 feet from 2009 to 2019 (Santa Cruz County Environmental Health, Steelhead Monitoring Data Explorer[33]). In 2007, average density for all age classes of *O. mykiss* in sampled units was 21 per 100 feet of stream in the Lower Reach, 15 per 100 feet in the Bedrock Reach, and 2 per 100 feet in the Upper Reach (HES 2007).

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[33] http://scceh.com/steelhead/data.aspx.

During the 1997 to 2015 time period, average density of size class II/III (75 mm SL or larger) steelhead in Newell Creek was among the highest for all consistently sampled sites in the San Lorenzo River and its tributaries (D.W. Alley & Associates 2016). Average density was nearly as good as the best mainstem sites and in the tributaries, only Zayante Creek and Branciforte Creek supported higher densities (Table 2-23). The high density of size class II/III fish relative to other parts of the basin indicates good rearing conditions in Newell Creek, and high potential smolt production.

Table 2-23: Steelhead Abundance Estimates in the San Lorenzo River Mainstem and Tributaries as Average Number of Size Class II/III (>=75 mm SL) per 100 feet of Stream at Consistently Sampled Locations from 1997 to 2015

Survey Location	Density	Location Description
San Lorenzo Main 2a	13.5	Gorge-Rincon
San Lorenzo Main 4	13.2	Henry Cowell
San Lorenzo Main 12b	12.4	Waterman Gap
San Lorenzo Main 0a	9.0	Santa Cruz
San Lorenzo Main 1	7.0	Paradise Park
San Lorenzo Main 11	6.0	Upper Mainstem
San Lorenzo Main 8	5.6	Brookdale
San Lorenzo Main 6	4.0	Felton Diversion
Zayante (13d)	16.3	
Zayante (13c)	15.2	
Branciforte (21b)	13.1	
Newell (16)	13.0	
Fall (15b)	12.6	
Bean (14b)	12.0	
Boulder (17b)	10.5	
Boulder (17a)	10.2	
Zayante (13a)	9.4	
Bear (18a)	9.4	
Branciforte (21a-2)	9.1	
Bean (14c)	7.8	
Lompico (13e)	6.9	

Source: excerpted from D.W. Alley & Associates 2016

Because of the relatively short reach of the anadromous portion of Newell Creek (0.8 to 1.0 mile), Newell Creek contributes a relatively small proportion of the San Lorenzo watershed steelhead production (Alley et al. 2004). If densities in Table 2-these fish were all anadromous, this would result in an estimate of about 580 smolts in the 0.85 miles of most productive habitat in the anadromous reach. Using the same 3% return rate, this would result in an estimated return of about 17 adult steelhead, on average, depending on ocean conditions and many other factors.

The primary limiting factors for salmonids in Newell Creek are related to habitat alteration from channel incision and riparian development and flow reduction during migration and spawning seasons due to operation of Loch Lomond Reservoir. Unlike the rest of the San Lorenzo watershed, fine sediments do not appear to be a significant issue in Newell Creek, possibly related to the fact that much of the smaller bedload from the upper watershed is deposited in Loch Lomond Reservoir. On the other hand, gravel and cobble substrate preferred by steelhead and coho are also deposited in the reservoir. Upstream passage of adults and spawning habitat availability are likely limited by low flows during winters when Loch Lomond Reservoir does not spill. Flow during the rearing period has been enhanced by operation of Loch Lomond Reservoir and temperature is cooler. The cooler temperature due to cold releases from Loch Lomond Reservoir may somewhat reduce growth rates but there is no clear evidence of this in recent basin-wide juvenile abundance surveys. In fact, given the warm temperatures in the lower San Lorenzo River, the slight cooling provided by Newell Creek may be beneficial to the system as a whole.

Population surveys in Mountain Charlie Gulch have been extremely limited. CDFW electrofished 16 sites within the survey reach and steelhead were found at all sampling sites. None were found above the migration barrier (ENTRIX, Inc. 2004b). During a survey in 2004, HES found the density of young of year *O. mykiss* averaged 110 per 100 feet in the survey reach and density of older *O. mykiss* averaged 8 per 100 feet. While difficult to draw firm conclusions from a single survey, these density estimates are within the range of observations from other San Lorenzo River tributaries.

Abundance (number of fish per 100 feet of stream) of both YOY and smolt sized steelhead in Zayante Creek has varied considerably from year to year, but on average, is among the highest of San Lorenzo River tributary areas surveyed (ENTRIX, Inc. 2004b). Given large annual variability in population sampling results over the past 9 years when consistent sampling has occurred (DW Alley and Associates 2007), there are no clear trends in abundance of rearing steelhead over time in Zayante Creek.

In Zayante Creek, the primary limiting factor for steelhead appears to be the excessive accumulation of fine-grained sediment in the substrate. The watershed has highly erodible soils and disturbance from unpaved or poorly maintained roads, landslides, debris flows, and residential development. The sedimentation is at a level that adversely affects aquatic habitat values (ENTRIX, Inc. 2004b). Lack of large woody material may also be a limiting factor as downed trees and limbs are frequently removed from the stream for the perceived benefit of avoiding flood damage, thereby reducing cover and resulting in more simplified habitat structure.

2.5.2 Coho (*Oncorhynchus kisutch*)

Listing Status and Distribution

Coho in the Plan Area are part of the Central California Coast ESU, which is listed as endangered under the federal ESA and under CESA.[34] Under the ESA, the Central California Coast ESU extends from Punta Gorda in Humboldt County south to, and including Aptos Creek (NMFS 2005b, NMFS 2012c). Critical habitat has been designated for the Central California Coast ESU, including the accessible portions of the streams in the Plan Area. NMFS published a recovery plan for Central California Coast coho in September (NMFS 2012). In spite of the protections afforded by these listings, the development of a recovery plan and ongoing implementation of many actions recommended in the recovery plan, the population has not stabilized and continues to decline (NMFS 2012).

Central California represents the southern margin of the species' natural distribution, and coastal streams of Santa Cruz County constitute the current southernmost extent of coho distribution (NMFS 2016c). Historically, coho were found in as many as 50 coastal drainages in San Mateo and Santa Cruz counties but spawning runs were limited to 11 stream systems by the 1960s (Anderson 1995). More recently, the two independent populations in the Santa Cruz Mountain diversity strata (Pescadero Creek and San Lorenzo River) were considered likely extirpated in the last NMFS 5-year status review (NMFS 2016c). Sporadic observations of coho continue to occur in Santa Cruz County streams, primarily the result of production from the Kingfisher Flat Hatchery in the Scott Creek watershed. For example, there was a release of 10,000 juvenile coho into Pescadero Creek in November 2020. Scott Creek experienced the largest coho run in a decade during 2014/15, and researchers recently detected juvenile coho within four dependent watersheds where they were previously thought to be extirpated (San Vincente, Waddell, Soquel and Laguna creeks) (NMFS 2016c). The increase appears to be related to improved hatchery strategies (Williams et al. 2016).

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[34] CCC coho (inclusive of coho south of San Francisco Bay) were listed as a federally threatened species on October 31, 1996 (61 Fed. Reg. 56138). Due to severe population declines between 1996 and 2004, NMFS relisted CCC Coho Salmon and changed its status from threatened to endangered (i.e., in danger of extinction throughout all or a significant portion of its range) on June 28, 2005 (70 Fed. Reg. 37160) (NMFS 2012). The State of California listed coho south of San Francisco Bay as a state endangered species in 1995 and listed the CCC Coho Salmon ESU as State endangered in 2002.

There has been some contention around the historical status and origin of coho populations south of San Francisco Bay (McCrary 2003, McCrary 2005, Spence et al. 2011). The NMFS status review of coho in Washington, Oregon, and California (Weitkamp et al. 1995) delineated the Central California Coast Coho Salmon ESU (CCC Coho Salmon ESU), as the southernmost coho ESU in the Pacific Northwest and California and determined that it comprised salmon spawning in streams and rivers from Punta Gorda in the north to and including the San Lorenzo River in central California, including tributaries of San Francisco Bay but excluding the Sacramento-San Joaquin River system (Weitkamp et al. 1995). The status review supported the NMFS listing of the CCC Coho Salmon ESU as "threatened" under the ESA in 1996 (61 Fed. Reg. 56138).

Coho have been introduced in Santa Cruz County streams since 1906, beginning with stocking fry reared at Brookdale Hatchery (San Lorenzo River) from as many as 500,000 eggs received from Baker Lake, Washington between 1906 and 1910, and in 1913 and 1915 (Spence et al. 2011). During the period 1929-1941 approximately 1.2 million coho fry were planted into waters of Santa Cruz and San Mateo Counties, with the majority of these being released in the San Lorenzo River, Scott Creek and its tributaries, and Soquel Creek (Spence et al. 2011). These fry were reared at Brookdale Hatchery and the newly established Big Creek Hatchery on Scott Creek with egg sourcing not always clear from the records but evidently, fish from Fort Seward (Humboldt County), Prairie Creek (Humboldt County), and Scott Creek provided broodstock during this period (Spence et al. 2011).

A twenty-year hiatus in supplementation between 1941 and 1962 has been followed by almost continuous planting of hatchery-produced coho. From 1963 to 1979, the California Department of Fish and Game planted a reported 446,159 coho in the San Lorenzo River, Aptos Creek, Soquel Creek, Scott Creek, Gazos Creek, and Waddell Creek. Brood sources for these plantings included Noyo River (58%), the Klaskanine and Alsea rivers in Oregon (13.5% and 10.8%, respectively), and the Green River in Washington (2.2%), with origin of the remainder (15.1%) unknown (Spence et al. 2011).

From 1980 to 1989, an attempt was made by Silver-King Ocean Farms (SKOF) to establish commercial aquaculture in the region. Over the 10-year period, SKOF released approximately 1.1 million coho (mostly YOY) into Davenport Landing Creek, a small seasonal stream near the town of Davenport. Broodstock for this effort consisted of a wide range of stocks, including a number of Washington and Oregon stocks, smaller numbers of fish from the Klamath and Noyo rivers in California, and hatchery fish that returned to Davenport Creek. Due to poor returns of adult fish and inability to attract them back to Davenport Landing Creek, this aquaculture venture was abandoned in 1989 (Spence et al. 2011).

Since 1976, the Monterey Bay Salmon and Trout Project (MBSTP) has reared and released coho from various broodstocks, including Ten Mile River, Noyo River, Russian River, Prairie Creek, as well as Santa Cruz County streams. Between 1991 and 2009 all broodstock were from Scott Creek and the

San Lorenzo River, with fish generally planted back into their stream of origin, except plantings of Scott Creek coho into Waddell Creek (2 plantings), Pescadero Creek (2 plantings), and Aptos Creek (1 planting) (Spence et al. 2011).

In 2003, NMFS received a petition to redefine the southern extent of the CCC Coho Salmon ESU to exclude populations that spawn in coastal streams south of the entrance to San Francisco Bay, arguing that historical accounts suggest the southern boundary of the CCC Coho Salmon ESU was at or north of San Francisco Bay; that there is a lack of evidence in the archaeological record of coho south of San Francisco Bay; that the physical environment of the Santa Cruz mountains is not conducive to persistent coho populations; and that coho that have occurred in this region for the last century are the result of introduction of nonnative stocks from locations north of San Francisco (McCrary 2003).

In response to the petition, NMFS determined that while there has been introduction of non-native coho stocks in the region, the petitioned action was not warranted. Specifically, NMFS relied on: (1) museum specimens of coho collected from four separate watersheds (Gazos, Waddell, Scott, and San Vicente creeks) south of San Francisco in 1895; (2) new archaeological evidence (published after the 2003 petition) establishing the presence of coho from the Año Nuevo region, and salmonid vertebrae from middens at Elkhorn Slough (northern Monterey County) and a late-1800s home site in Santa Barbara tentatively identified as coho; (3) evaluation of environmental conditions with the conclusion that they are not appreciably different from watersheds immediately to the north where the historical occurrence of coho is not in dispute; and (4) genetic evidence identifying contemporary coho populations south of the Golden Gate as genetically part of the CCC Coho Salmon ESU, and while not ruling out some contribution of fish imported from other populations within the CCC Coho Salmon ESU (e.g., the Noyo River), ruling out the possibility that contemporary coho populations south of the Golden Gate are entirely the result of such importations (Spence et al. 2011). NMFS also determined that the effectiveness of early hatchery practices is questionable and likely led to low return rates of adult fish since the practice of releasing fish as fry likely led to very low survival rates, and stock from distant and more northern sources like Baker Lake evolved in a cold, snow-melt driven system with adaptations such as summer adult run timing that would be highly maladaptive in the Santa Cruz Mountain region (Spence et al. 2011).

As part of its review in response to the petition, NMFS concluded that the CCC coho ESU should be extended southward from its previously defined southern limit at the San Lorenzo River to include the Soquel and Aptos creek watersheds. This conclusion was based on the ecological similarity and close proximity of the Soquel and Aptos creek watersheds to those immediately to the north, coupled with the documented natural recolonization of the Soquel Creek watershed by coho during the 2007–2008 spawning season (Spence et al. 2011).

Although there is good evidence that coho were present in the Plan Area before extensive hatchery influence, only rough estimates exist of the historical coho adult abundance and those estimates are only available since the 1940s (NMFS 2012). Lack of information for how abundant or persistent these early populations were is not an inconsequential consideration in development of this HCP and recovery of the species. The inherent capacity of habitat in the Plan Area to support coho bears heavily on the responsiveness of the species to management actions in Plan Area streams, even if all human influence could be removed or remediated.

Life History and Habitat Requirements

Coho spawning migrations from the ocean to freshwater streams or rivers usually begin after the first heavy rains in late fall or winter. The timing of their migration varies somewhat throughout their range, but in the short coastal streams of central California, coho typically return to fresh water during November through February with the peak in December and January. Females construct redds near the head of a riffle in substrate consisting of gravel and small cobble. The female may dig several pits to complete spawning, probably laying a few hundred eggs in each pit. Coho average 2,500 eggs per female. Shapovalov and Taft (1954) found that the average incubation time for coho on Waddell Creek was 35 to 50 days.

Temperatures at this time should not exceed 55ºF (12.8°C) (Shapovalov and Taft 1954). Newly hatched fry (embryos) remain in the interstices of the gravel for approximately 3 weeks before emerging and schooling in still, shallow water along stream margins. As they grow during the spring, juvenile coho disperse to pools where they set up individual territories. After spending the ensuing summer, fall and winter in the stream, the immature yearling coho begin to migrate downstream toward the ocean in spring. During this time, juveniles undergo smoltification. Growth in freshwater varies with a number of factors, but typically smolts leaving California streams at 12-15 months old measure 8 to 15 centimeters (cm) FL. Some juveniles may achieve even larger sizes before emigration by staying 2 years in the stream (Moyle 2002). Outmigration typically peaks from late April to mid-May, if conditions are favorable (Moyle 2002). After entering the ocean, immature coho initially remain inshore, close to the parent stream. Gradually, they spread out, over the continental shelf, where they grow much more rapidly than in the stream.

Coho have a fairly strict 3-year life cycle, with about half spent in freshwater and half spent in salt water. After 2 years of growing and sexually maturing in the ocean, coho return to their natal streams as 3-year-olds to spawn and die. Some precocious males (jacks) return to freshwater at two years of age (NMFS 2012). There is very little variability in age of spawning for female coho with the result that nearly all wild female CCC coho spawn at three-year old (Anderson 1995, Shapovalov and Taft 1954). This results in distinct brood-year lineages with the majority of progeny in any year class produced by females hatched three years previously. If a particular brood-year is lost or depleted due to catastrophic events such as wildfire, flood, poor ocean survival, or chemical spills, it is very difficult for it to rebuild. For coho south of San Francisco Bay, Anderson (1995) reported the extirpation of the 1991-1994 lineage in Waddell and Scott Creeks (the only streams south of San Francisco Bay still sustaining natural runs at that time) and the near elimination of the 1992-1995 lineage on both streams. At that time, only the 1993-1996 lineage was sustaining (Anderson 1995).

Shapovalov and Taft (1954) found the average rate of survival for coho was 0.13 percent from the egg to adult return (varying from .02 to 0.3 percent in different seasons), and survival from the entrance into the ocean to adult return averaged 2.3 percent (ranging in different seasons from 0.6 to 5.4 percent). Rates of survival tend to vary inversely with the size of the year class (Shapovalov and Taft 1954). Rates of survival are highly variable both during freshwater and ocean residence.

Habitat requirements for coho are variable and depend on life stage. Key habitat features are summarized in the CCC coho recovery plan as follows (NMFS 2012). Adults returning from the ocean to spawn need adequate flows to migrate upstream and cool temperatures. Deep pools for resting and cover from overhanging riparian vegetation, downed trees, rootwads, and undercut banks are beneficial for protection from predation. Gravel/cobble substrate free of fine sediments and with adequate flow through the pore spaces is selected by females for laying eggs.

After laying eggs, stable streamflows are beneficial so that sufficient flow is maintained through the gravel to irrigate developing embryos. Significant declines in streamflow during the incubation period can dewater redds and floods can mobilize the substrate and destroy redds and eggs or fill voids in the gravel with fine sediments and smother eggs. Incubation of eggs is optimal in stable, undisturbed substrate supplied with adequate flows of clean, well-oxygenated water not contaminated with toxic substances. After hatching, alevins remain in the small spaces between the gravels and feed from their attached yolk sacs. They are highly vulnerable to siltation and scour and need to be able to swim up through the gravels and emerge into open water.

Free-swimming fry feed on small invertebrates of both aquatic and terrestrial origin. Deep pools with extensive cover and cool temperatures become important as juveniles rear over their first summer. Dense riparian vegetation supports some of the insects consumed by juveniles, provides cover from potential predators, and maintains cooler temperatures by limiting solar radiation. Large trees bordering the stream also moderate temperature and dense root systems provide cover and stabilize stream banks. CCC coho are strongly associated with redwood forests. Downed trees and branches and accumulations of same (debris jams) provide important instream habitat functions such as hydraulic and habitat diversity, substrate for production of invertebrates, shelter from high flows, cover from potential predators, storage of fine sediment, and deposition of gravels and cobble. Side channels with pool habitat provide refuge during high flow periods.

After their first year in freshwater juvenile salmon undergo a physiological change known as "smoltification" that enables them to transition from freshwater to seawater. Smoltification can occur primarily with freshwater or in the nearshore environment. Smoltification is accompanied by downstream migration from rearing habitat to the ocean and migration success is enhanced by sufficient flow to move efficiently and safely downstream without impediment. In some streams coho use estuaries or lagoons during this transition, in others they migrate directly from freshwater to the sea with little time in an estuary. In streams where time is spent in an estuary, the quality of the habitat in terms of production of food, ability to evade predation, and water quality conditions are important factors.

Maturation of sub-adults occurs during ocean residency over a two-year period, leading up to the adult salmon's return, usually to the stream of its birth. The patterns of migration in the ocean vary and shifts in ocean conditions affect food, migration patterns, and survival. As the salmon return to their natal stream to reproduce they undergo change from saltwater to freshwater and may depend on nearshore or estuarine environments for this transition.

Population status and Limiting Factors

Only rough estimates exist for historical CCC coho adult abundance. Assessing changes in the viability of the CCC-Coho Salmon ESU remains a challenge due to the scarcity of long-term datasets for most populations, although implementation of the California Coastal Salmonid Population Monitoring Program (CMP)[35] across significant portions of the ESU have resulted in a number of shorter time series since 2010 (Williams et al. 2016). The existing data indicate that all independent and dependent populations are well below recovery targets and, in some cases, exceed high-risk thresholds (Williams et al. 2016). Although the longer-term (12–17 year) trends tend to be downward, data from the past 5 years suggest that some populations reached their lowest levels around 2008–2009 and have rebounded slightly since then. An area of particular concern is the downward trends in abundance of virtually all dependent populations across all diversity strata. These trends suggest that dependent populations are less able to maintain connectivity or act as buffers against declines in neighboring independent populations, suggesting that the independent populations are becoming more isolated with time. Populations continue to be the strongest in the Mendocino County watersheds from the Navarro River northward, and weaker to the south, with the exception of Lagunitas Creek. The viability of coho in the Santa Cruz Mountain Diversity Stratum, where virtually all recently observed salmon have been the result of hatchery operations, remains especially dire. The CCC-Coho Salmon ESU continues to be in danger of extinction (Williams et al 2016).

North Coast

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[35] https://www.calfish.org/ProgramsData/ConservationandManagement/CaliforniaCoastalMonitoring.aspx

Sampling for salmonids in the North Coast streams has been limited to the synoptic survey of Santa Cruz County streams in the fall of 1981 by Harvey & Stanley Associates, Inc. (1982), annual snorkel surveys conducted by the City of Santa Cruz since 2006, and lagoon surveys in Laguna Creek conducted since 2004. The 1981 surveys were conducted by electrofishing at "spot checks" in representative locations. All sites in Laguna Creek and all but three sites in Liddell Creek and 1 site in Majors Creek were above currently identified limits of anadromy. The year the survey was conducted, 1981, was a dry year with low streamflows. No coho were reported in any of the three Creeks in the HCP area (Liddell, Laguna, or Majors) in the 1981 study.

The City of Santa Cruz annual surveys involve snorkel surveys throughout the anadromous reach of each stream and cover a total distance of 2,000 to 3,000 linear feet in each stream. A few coho have been observed in the snorkel surveys. A carcass of a spawned adult coho was found by City of Santa Cruz personnel in the winter of 2005 (Chris Berry, City of Santa Cruz, personal communication to Jeff Hagar, 2006). Seven YOY coho were observed in snorkel surveys in Laguna Creek in 2015 and four age 1+ coho were observed in 2016 (Berry et al. 2019). Three coho YOY were also observed in Liddell Creek in 2018 (Berry et al. 2019). Smolt-sized and YOY coho were captured in seining surveys in the Laguna Creek lagoon in 2005 (2ndNature 2006) indicating that coho spawned successfully in Laguna Creek both during the winter of 2003-2004 and the winter of 2004-2005. Coho YOY were relatively abundant in the lagoon in May and July but had largely disappeared by September (2ndNature 2006). These observations indicate that suitable conditions for coho reproduction in at least Laguna and Liddell Creeks in some years. This production is likely the result of natural spawning by hatchery produced fish.

As in other Santa Cruz County streams, the North Coast streams are near the southern range limit of coho. Factors thought to limit coho in these streams include: extreme hydrologic variability typical of the Central California Coast, including frequent droughts and high peak flows; and the narrow and early coho spawning season and inflexible coho life history that subject the coho to catastrophic losses on a frequent basis and provide little ability to rebound during brief periods of more suitable conditions. In addition, the high sedimentation levels and lack of pool development in Liddell Creek are at least as limiting for coho as for steelhead.

According to watershed characterization protocols developed in the NMFS Recovery Plan for Central California Coastal coho (NMFS 2012), Majors, Laguna, and Liddell creeks are described as Dependent Populations. In general, under current conditions neither Majors nor Liddell likely maintain suitable spawning and rearing conditions for coho. Long-term persistence in Laguna Creek is likely tenuous due to the relatively small quantity of accessible habitat coupled with the significant amount of water diverted from the upper watershed (NMFS 2012).

Climatic conditions affect salmonid abundance, productivity, spatial structure, and diversity through direct and indirect impacts at all life stages and while salmon have adapted to a wide variety of climatic conditions in the past and could likely survive substantial climate change at the species level, the adaptive ability of these species is currently depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation (Williams et al. 2016). Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many of these ESUs and DPSs (Williams et al. 2016). This is particularly for those populations, such as the San Lorenzo River and dependent populations on the North Coast, at the margins of the species range. The period from 2012-2015 in California was characterized by well below average precipitation in each year and may be the most extreme drought in the past 500 years. The drought was accompanied by record high surface air temperatures in 2014 and 2015 which amplified annual water deficits (Williams et al. 2016).

San Lorenzo River Unit

Anderson (1995) reported that coho were abundant and supported a significant sport fishery on the San Lorenzo River into the 1960s, when a severe population decline occurred. Estimated annual river sport catch was 200 -1,500 adult coho (Anderson 1995). By the early 1970s the river sport catch had declined to 383 adults in 1970-71, 370 adults in 1971-72 and 342 adults in 1972-73, (Anderson 1995). The decline in the San Lorenzo River coho sport catch in the 1970s reflected a corresponding drastic decline in the annual coho spawning runs (Anderson 1995). Estimated escapement in the San Lorenzo River was 1,600 in 1963 and 500 in 1984-1985 (NMFS 2012).

In an effort to reestablish coho runs for River recreational fishing, the MBSTP started a hatchery coho smolt planting program in 1986 primarily using eggs from Noyo River and Prairie Creek stocks. As returning runs developed, MBSTP began capturing adults by seining the lagoon or operating the Felton Diversion Dam Trap and artificially spawning them to produce eggs and smolt. These progeny of non-native coho stocks were used to restock the River (Anderson 1995 citing MBSTP Annual Reports, Brown et al. 1994). Although small returning runs developed which generated some local interest in a winter sport fishery for sea-run salmon, these runs failed to produce a naturally spawning population (due in part to lost and degraded habitat conditions and the non-native ancestry of the San Lorenzo River coho), and the resultant runs are entirely hatchery-maintained (Anderson 1995 citing Brown et al. 1994, Bryant 1994).

Recent sampling within Pescadero Creek and San Lorenzo River, the only two independent populations within the Santa Cruz Mountains strata, suggest coho have likely been extirpated within both basins (NMFS 2016c). The San Lorenzo River lost its naturally spawning coho population during the 1976-1977 drought. However, much or all of that population was the result of stocking from the

1950s through the mid-1970s (Brown et al. 1994). Basin-wide salmonid abundance surveys of the San Lorenzo River and tributaries, conducted from 1994 through 2004 failed to capture a single coho (Alley et al. 2004, Alley 1994-2001, Santa Cruz County Environmental Health 2020). Four juvenile coho were observed in Bean Creek (tributary to Zayante Creek) in the fall of 2005 (DW Alley and Associates 2007) and two YOY coho were captured in September 2005 in Zayante Creek just upstream of the Bean Creek confluence (HES 2005a). YOY coho were also observed by NMFS in 2005 during snorkel surveys in Bean Creek (Brian Spence personal communication to Chris Berry, 2005). Based on accounts in the literature, these were likely progeny of hatchery strays (Brown et al. 1994, Anderson 1995, Williams et al. 2016).

Extirpation of coho from the San Lorenzo River is likely a result of habitat loss and drought conditions in the late 1980s, and early 1990s (NMFS 2012). The severe drought of 1976-77 also had impacts. The period of severe population decline in the 1960s and early 1970s noted by Anderson (1995) was associated with the effects of booming residential growth in the watershed, including disturbance of land, increased erosion, and deposition of fine sediments in the streambeds (Alley et al 2004, County of Santa Cruz 2001, NMFS 2012). Anderson (1995) cites reports that fine sediments within the San Lorenzo River streambed increased from 8 percent in 1961 to 65 percent in 1972, confirming an observed dramatic increase in sediments during the 1960s -1970s, concurrent with the decline of the coho spawning population. (Anderson 1995).

Factors limiting coho in the San Lorenzo River are similar to those for steelhead, primary among which are the lack of deep pools, high stream channel gradient, high summer temperatures, and hydrologic patterns which result in low flows for early upstream passage during November and December (which is critical for coho) and excessively high flood flows that are destructive to redds during late winter and early spring. In addition, habitat preferred by coho, including low gradient streams in old-growth coniferous forest with deep pools and lots of woody cover, is not extensive in the San Lorenzo River watershed. The San Lorenzo River is at the extreme southern boundary of the species range (Spencer et al. 2004) and as such, any one of a number of factors may be limiting. Limited water temperature studies have indicated that areas in the San Lorenzo River watershed with otherwise suitable habitat conditions and highest intrinsic potential for supporting coho, such as the lower mainstem and lagoon, have temperature conditions that often exceed the suitable range for coho (Section 2.4.3.1). The extreme hydrologic variability typical of the Central California Coast, including frequent droughts and high peak flows, may be the single most limiting factor for coho. The narrow and early coho spawning season and inflexible life history subject the coho to catastrophic losses on a frequent basis and provide little ability to rebound during brief periods of more suitable conditions (Anderson 1995).

NMFS has identified numerous anthropogenic induced factors leading to a decline in habitat quality, including urbanization, water diversions, inadequate road management practices coupled with high road density, large wood removal, past timber harvest practices, bank hardening, and channelization (NMFS 2012). Many of the low gradient habitats in the lower portion of the watershed with high Intrinsic Potential to support coho are extensively urbanized and their function as coho rearing habitat is compromised (NMFS 2012).

In Newell Creek, the factors most limiting for coho, aside from their overall status in the watershed, are likely to be low flows during the adult migration and spawning periods. This is potentially even more of a problem for coho than for steelhead since coho are dependent on early migration (December and January) when Loch Lomond Reservoir is less likely to have filled enough to spill.

In Zayante Creek, excessive accumulation of fine-grained sediment in the substrate is likely to be limiting in absence of these other factors. A lack of large woody material is also a likely limiting factor for steelhead and coho.

3.0 COVERED ACTIVITIES

3.1 Introduction

This section describes the “Covered Activities” under the HCP, including rehabilitation of water system facilities, operations and maintenance activities that the City routinely performs including operation, maintenance and repair of the City’s water supply and water system facilities, operation and maintenance of the City’s municipal facilities such as the San Lorenzo River flood control channel, management of City open space and other lands and emergency response. More detail on these activities is provided below. See Figure 3-1: City of Santa Cruz Water System map.

Figure 3-1: City of Santa Cruz Water System Map

3.2 Rehabilitation of Diversion Structures and Pipeline Reaches

The North Coast System (NCS) is the part of the City's water system that diverts water from Liddell Spring, Laguna Creek, Reggiardo Creek and Majors Creek and delivers that water to the Coast Pump Station; located along the San Lorenzo River just upstream of Highway 1 in Santa Cruz. The NCS is located within the Coastal Zone of Santa Cruz County (Figure 1-1). The NCS includes five distinct pipeline reaches (Liddell, Laguna, Laguna/Liddell, Majors, and the North Coast Pipeline Reach [NCP Reach]). The system extends above ground and underground through developed and undeveloped areas, and traverses along, above or beneath roadways and waterways from Bonny Doon to the west side of Santa Cruz. See Figure 3-1: City of Santa Cruz Water System map. Rehabilitation work on the NCS entails replacement of portions of the supply pipelines and rehabilitation of the diversion structures. The pipeline replacement work includes replacement of the pipelines in their current alignments or the construction of new alternative alignments, designed to avoid sensitive habitats (e.g., potentially sensitive riparian areas). Due to the size of the NCS and funding limitations, work on each of the five pipeline reaches will occur in phases and includes a mix of existing and new alignments. It is also possible that the pipeline routing may require a change from the present "gravity-flow" system to a "pumped" system for the Laguna and/or Majors reaches.

Under the proposed Project, rehabilitation of the two 120+-year old diversion structures at Majors and Laguna Creeks also would occur. Modifications to these structures, which are located above the anadromous reaches on the creeks, would likely include dewatering by way of the installation of a cofferdam and a temporary bypass system, earthwork, reinforced concrete demolition and construction, metal work fabrication and installation, bank armoring, and miscellaneous electrical and mechanical services, including a pneumatically operated spillway gate. This work would enable the diversion structures to facilitate bypass flows and passage of suspended sediment and bed load downstream in a more natural manner, minimizing the need for manual clearing of these materials and deposition in downstream habitat. Rehabilitation of the Tait Street and Felton Diversions on the San Lorenzo River would also occur and primarily involve improvements for fish passage, screening and pumping capacity (at Tait Street only) to take advantage of high winter flows, thereby allowing deferral of winter pumping at North Coast diversions and improvements in groundwater storage that can serve water system demand during low flow periods.

The City maintains an 8- to 10-foot right-of-way (ROW) along the existing pipeline route in most areas. Specifically, the18-mile NCS includes:

- approximately 5.5 miles of the system located within developed areas (mountain residential and City of Santa Cruz)

- approximately 1.5 miles of the system extending beneath City surface streets from the Meder Street extension to High Street
- approximately 4 miles of the system running along Highway 1 from Laguna Creek on the west to Wilder Ranch State Park entrance on the east (Jones & Stokes 2000)
- the remaining 12.5 miles of the system running through undeveloped areas (Cotoni-Coast Dairies National Monument, Wilder Ranch State Park, and Moore Creek Preserve)

3.3 Water Supply Operations

3.3.1 Water Diversions

The City has several sources of water supply in its system. These include the North Coast Diversions (including Liddell Spring, Reggiardo Creek, Laguna Creek and Majors Creek), the San Lorenzo River (including Felton and Tait Street Diversions), Newell Creek Dam and Reservoir (commonly referred to as Loch Lomond Reservoir) and the Live Oak Wells. While drought-period demand is substantially lower, the historic and projected future water demand in the service area averages about 3.2 billion gallons annually, of which the majority occurs in the six-month May-October peak season. Historically, only the Felton Diversion and Newell Creek Dam had requirements for bypass flows. The Live Oak Wells draw from deep groundwater with no clear, direct connection to surface water dynamics and are not addressed in this HCP (Montgomery and Associates 2020).

The HCP will provide coverage for existing water diversion facilities including operation, rehabilitation, replacement, repair and maintenance of existing infrastructure and related facilities such as water measurement devices, scientific measuring devices, and water quality monitoring stations. The level of diversion for each facility is based on bypass flows ("Conservation Flows") negotiated for anadromous salmonids for the City's HCP. Conservation Flows for minimization of biological effects resulting from water diversion will be discussed in detail in the conservation strategy.

Liddell Spring Diversion

The Liddell Spring Diversion was developed in 1913 and is a natural spring located at the headwaters of the East Branch of Liddell Creek, approximately 2.5 miles upstream from the mouth of Liddell Creek and 1.34 miles from the anadromous limit (See Figure 3-1: Water System map). The spring box/diversion structure consists of a concrete box with a corrugated locking door. The structure sits on top of the natural spring and is approximately 25 feet above Liddell Creek. Because the water right for the diversion is a pre-1914 right there are no specified limits on diversion rates or quantities and a bypass flow is not required.

The Liddell Spring Diversion operates year-round and historically produced approximately 1.2 to 1.7 million gallons per day (mgd) with a maximum facility diversion capacity of approximately 2.5 cfs prior to recent implementation of bypass flows. Future diversion capacity increases are not proposed for coverage in this HCP. See Section 6.2.1 for a discussion of water supply reliability – related future water rights changes associated with this facility. Water is diverted directly from the spring into a 10-inch pipeline that then connects to the North Coast Pipeline via the Laguna Creek pipeline. The flow is controlled by an inline slide gate valve. The valve may be shut during storms and a separate drain valve is most often cracked open to allow sediment transport and passing of the peak of the hydrograph. Sediment is also removed via pumping when it inundates the drain valves during significant storms. When not diverted, the spring flow passes under the access road adjacent to the spring through a culvert and discharges into a tributary to the East Branch of Liddell Creek. See Figure 3-2: Liddell Diversion Schematic and Figure 3-3: Laguna Diversion photo.

Figure 3-2: Liddell Diversion Schematic

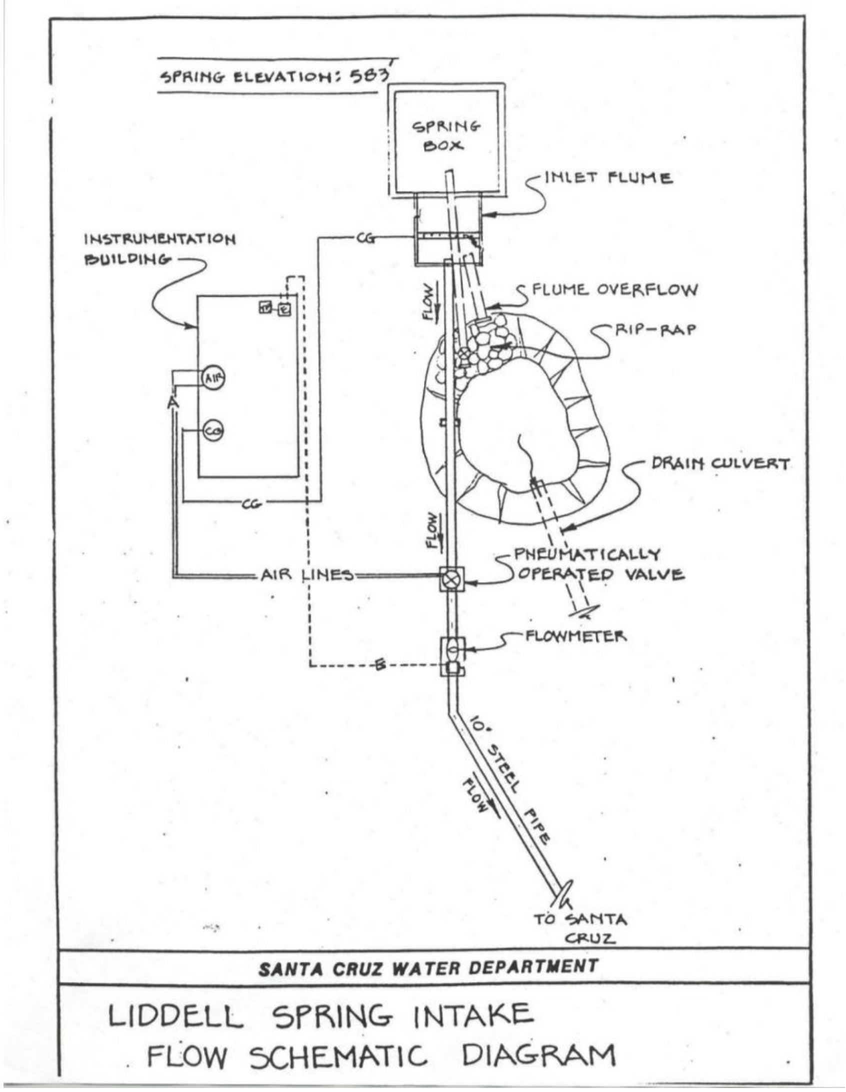


Figure 3-3: Liddell Diversion

Photo: Looking upstream from right bank toward the Liddell Diversion

Reggiardo Creek Diversion

The Reggiardo Creek Diversion is located on Reggiardo Creek approximately 300 feet above its confluence with Laguna Creek (See Figure 3-1: Water System map). Water rights for the Reggiardo Creek Diversion were acquired along with Laguna Creek in about 1912 (Camp, Dresser & McKee 1996). Since the diversion is part of a pre-1914 water right, there are currently no legal restrictions on diversion rates or quantity from the diversion nor is there a bypass flow requirement. A concrete dam spans the full width of the creek and is approximately 10 feet high. Immediately behind the concrete dam, the channel is filled with sediment. A small pond is created at the crest of the concrete dam.

The Reggiardo Creek Diversion typically operates year-round, 24 hours a day. However, due to recent inundation by sediment, the diversion is currently inoperable. Historic maximum facility diversion capacity ranged from 1.6-2.8 cfs. Surface water diverted from Reggiardo Creek enters a 14-inch pipe and flows by gravity approximately 850 feet into the upstream side of the Laguna Creek Diversion pond. A valve is located at the discharge of the pipe allowing flow to be regulated or shut off completely. Future diversion capacity increases are not proposed for coverage in this HCP. See Figure 3-4: Laguna/Reggiardo Diversion Schematic, Figure 3-5 Reggiardo Diversion Schematic and Figure 3-6 Reggiardo Diversion photo.

Figure 3-4: Reggiardo and Laguna Creeks Diversions Schematic

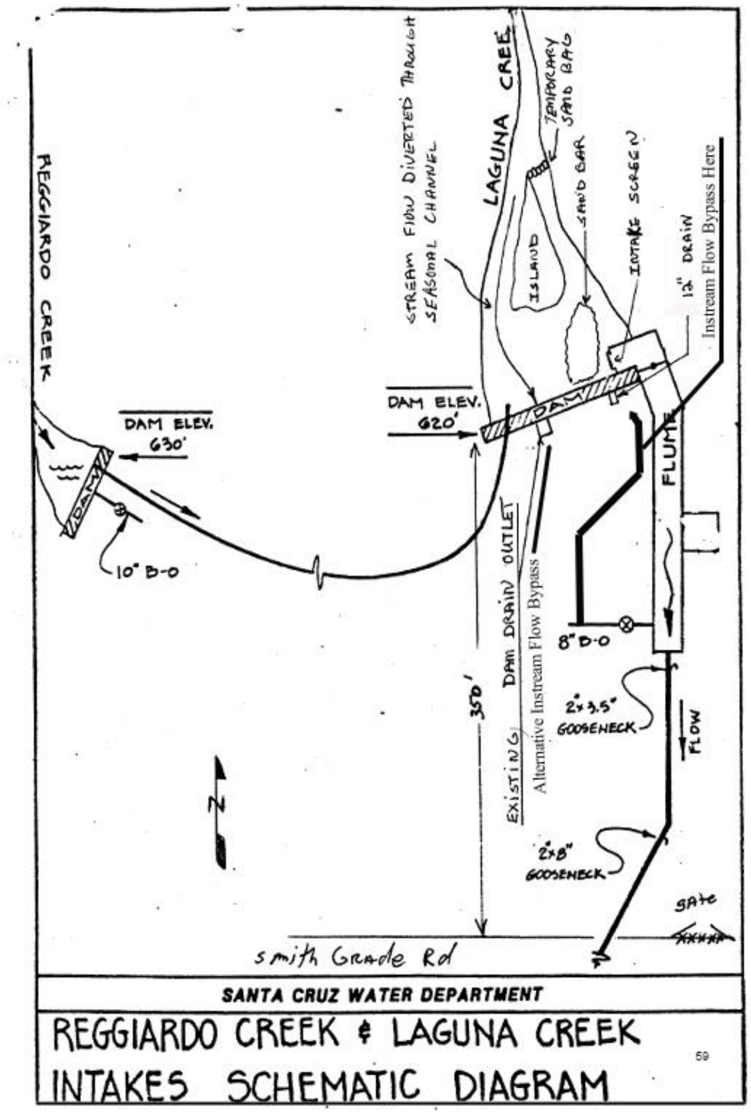


Figure 3-5: Reggiardo Diversion Schematic

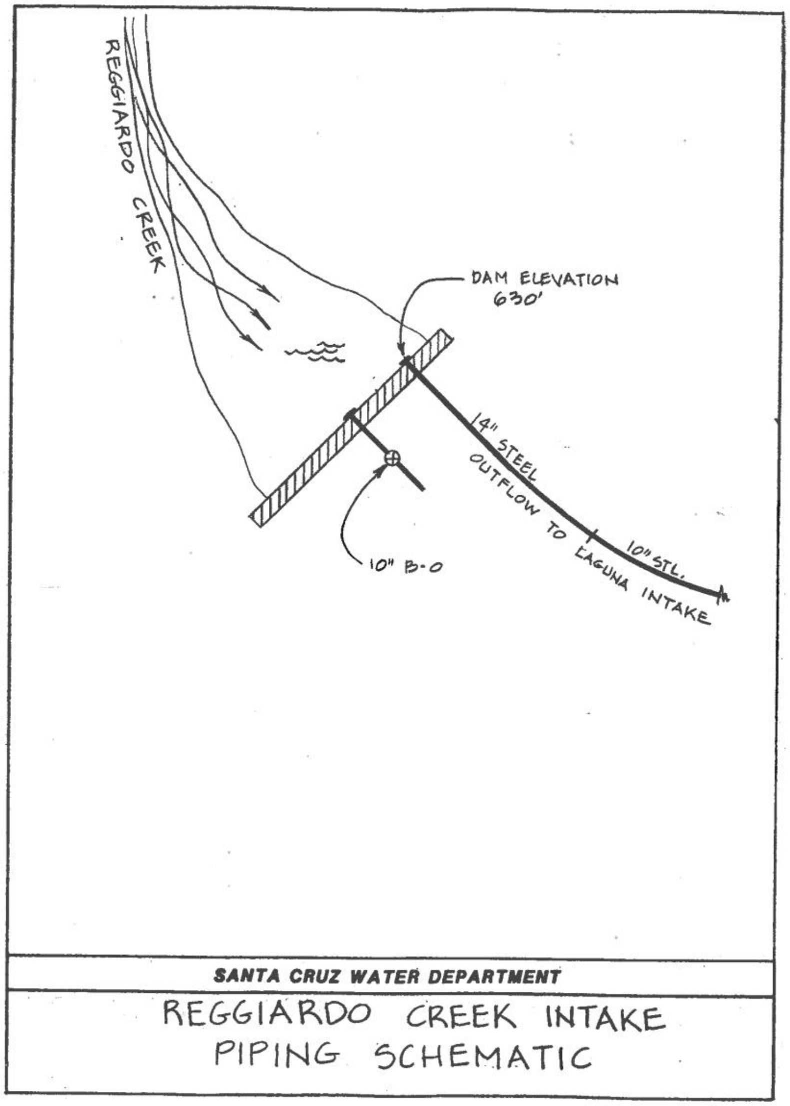


Figure 3-6: Reggiardo Diversion

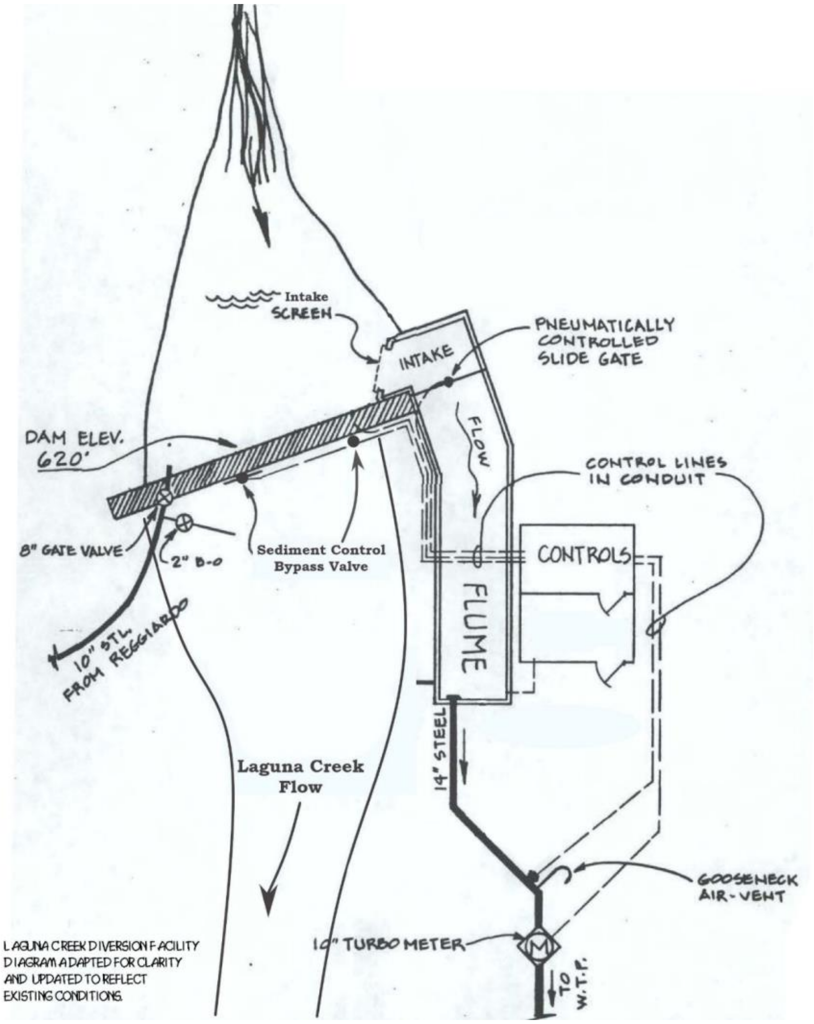
Photo: Reggiardo Diversion from right bank downstream looking across the channel

<u>Laguna Creek Diversion</u>

The Laguna Creek Diversion is located 4.23 miles upstream from the mouth and 2.8 miles upstream from the anadromous limit (See Figure 3-1: Water System map). It was developed as a water source in 1890 and remains in use currently. Since the diversion is part of a pre-1914 water right, there are currently no legal restrictions on diversion rates or quantity from the diversion nor is there a bypass flow requirement. The concrete dam limit spans the full width of the creek and is approximately 12 feet high. Immediately behind and below the dam are small pools, however sediment has substantially filled the upstream pool.

The diversion operates year-round and has no seasonal restrictions nor bypass requirements. The maximum diversion capacity is approximately 6.3 cfs. Future diversion capacity increases are not proposed for coverage in this HCP. See Section 6.2.1 for a discussion of water supply reliability – related future water rights changes associated with this facility. The intake passively diverts water from the impoundment pool through a 5/32 inch woven-wire intake screen. This screen acts to keep debris from entering the intake pipeline and is periodically cleaned of debris by hand. Water enters a flume that conveys flow to the 14-inch pipeline. A pneumatically operated (air pressure) slide gate at the inlet of the pipe is used to open or close the inlet. During storm events the diversion intake is shut down as turbidity rises above 25 Nephelometric Turbidity Units (NTU). When turbidity begins to fall below 25 NTU the diversion is turned back on. Water from the diversion is transported through a 14-inch pipeline to the junction of the transmission pipeline from Liddell Spring. After joining at the Liddell junction, the raw water is transferred via the North Coast Pipeline to the water system. See Figure 3-7: Laguna Diversion Schematic and Figure 3-8 Laguna Diversion photo.

Figure 3-7: Laguna Diversion Schematic



LAGUNA CREEK DIVERSION FACILITY DIAGRAM ADAPTED FOR CLARITY AND UPDATED TO REFLECT EXISTING CONDITIONS.

Figure 3-8: Laguna Creek Diversion

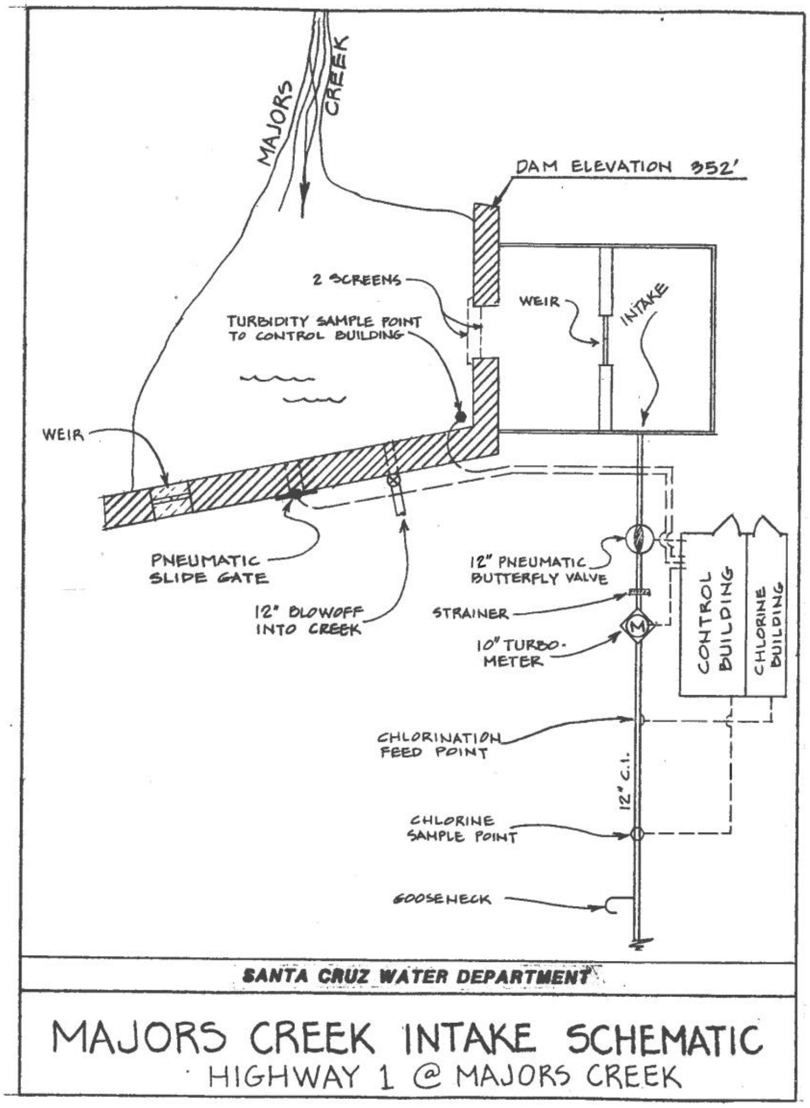
Photo: Laguna Creek Diversion from right bank downstream looking across the channel

<u>Majors Creek Diversion</u>

The Majors Creek Diversion is located 2.2 miles upstream from the mouth and 1.5 miles upstream from the anadromous limit (See Figure 3-1: Water System map). Diversion on Majors Creek has occurred since 1882. The water right for the diversion was established in 1881 and the City operates the diversion under the pre-1914 water right (Camp, Dresser & McKee 1996). The Majors Creek Diversion operates year-round and has no seasonal restrictions nor bypass requirements. The concrete dam spans the full width of the creek and is approximately 12 feet high. Immediately behind and below the dam are small pools which are periodically inundated by the high sediment loads present in Majors Creek.

The diversion operates year-round and has no seasonal restrictions nor bypass requirements. The maximum diversion capacity is approximately 2.1 cfs. Future diversion capacity increases are not proposed for coverage in this HCP. See Section 6.2.1 for a discussion of water supply reliability – related future water rights changes associated with this facility. The intake passively diverts water from the impoundment pool through a 1/4 inch woven-wire intake screen. This screen acts to keep debris from entering the intake pipeline and is periodically cleaned of debris by hand. Water enters a flume that conveys flow to the 12-inch pipeline. A pneumatically operated (air pressure) slide gate at the inlet of the pipe is used to open or close the inlet. During storm events the diversion intake is shut down as turbidity rises above 25 NTU. When turbidity begins to fall below 25 NTU the diversion is turned back on. Water from the diversion is conveyed through a 12-inch pipeline to the North Coast Pipeline. The Majors Creek Diversion is located approximately 300 feet lower in elevation than the other North Coast diversions, thus use of the Majors Creek Diversion is presently limited by the hydraulic loading from the other north coast sources. This hydraulic condition affects the influence that this diversion has on hydrology downstream by limiting Majors Creek diversion potential when production from the Liddell and Laguna diversions is relatively high. See Figure 3-9: Majors Diversion Schematic and Figure 3-10: Majors Diversion photo.

Figure 3-9: Majors Diversion Schematic[36]



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[36] Chlorine is no longer used at the diversion.

Figure 3-10: Majors Diversion

Photo: Majors Diversion from left bank downstream looking across the channel

Newell Creek Diversion and Loch Lomond Reservoir

The Newell Creek Diversion consists of the Loch Lomond Reservoir impounded by the Newell Creek Dam (commonly referred to as Loch Lomond). Loch Lomond Reservoir is located on Newell Creek approximately 1.7 miles upstream from the confluence with the San Lorenzo River and 0.7 miles upstream of a significant migration barrier (See Figure 3-1: Water System map). Loch Lomond Reservoir is a drinking water reservoir and is the City's only water storage facility. Loch Lomond Reservoir is approximately 2.5 miles long with an approximate width of 1,500 feet. Newell Creek extends 3 miles upstream of the upper end of the reservoir. In 2009 the maximum volume of Loch Lomond Reservoir was determined to be 8,646 acre-feet (McPherson et al. 2011).

The Newell Creek Diversion (License No. 9847) is an appropriative right for diversion to storage not direct diversion to use. This license allows for a maximum of 5,600 acre feet or 1,825 million gallons per year to be collected from September 1 to July 1 and requires a year-round release of 1 cfs to Newell Creek downstream of the reservoir and release of the natural flow during July/August (due to the fully appropriated status of the San Lorenzo watershed) if the natural inflow exceeds 1cfs. Withdrawals from Loch Lomond Reservoir under the Newell Creek water right can occur from January 1 through December 31 and is limited to 3,200-acre feet or 1,042 million gallons per year. See Section 6.2.1 for a discussion of water supply reliability – related future water rights changes associated with this facility. Water that is removed from storage is passed through a valve on the dam face and flows by gravity to the Felton Booster Pump Station for delivery to the Graham Hill Water Treatment Plant.

Legal action taken by the SLVWD subsequent to the date the City obtained the Newell Creek license, resulted in a court decision that provides SLVWD up to 313 acre-feet or 102 million gallons per year from Loch Lomond Reservoir. This leaves a maximum withdrawal for the City of approximately 2,890 acre-feet or 940 million gallons per year from Newell Creek Reservoir.

The Felton Diversion on the San Lorenzo River also provides water to Loch Lomond Reservoir under two separate diversion to storage water rights permits. This water does not count against the provision in the Newell Creek license nor the SLVWD court decision. Details on the Felton Diversion are provided below.

Newell Creek Dam has five water intakes spaced at 20-foot intervals from 550 to 470 feet above sea level respectively, allowing withdrawals from the level with the best water quality, usually either 510 or 490 feet. Loch Lomond Reservoir is oxygenated by a hypolimnetic aerator[37] during the summer/fall months. The Newell Creek Diversion bypass is provided through a valve at the base of the Newell Creek Dam located approximately 10 feet from the toe of the dam.[38] The water released from this bypass is from the level of draw that is also used for production – which is aerated by the aforementioned hypolimnetic aerator, as well as by the diffuser at the outlet from the dam to Newell Creek just below the dam. Due to the small size of Loch Lomond Reservoir, spilling often occurs in years of average to above average rainfall. See Figure 3-11: Newell Creek Diversion Schematic and Figure 3-12: Newell Creek Diversion photo.

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[37] Hypolimnetic aeration, involves the oxygen demand of deep water being provided by oxygen from the atmosphere via mechanical methods without destroying the lake's natural stratification. As the deep water becomes aerobic, the phosphate dissolution is reduced significantly and the mineralization of sediments improves - thereby improving water quality and conditions for cold water fish species.

[38] The future location of this release will be adjacent to the spillway pond.

Figure 3-11: Newell Creek Diversion Schematic

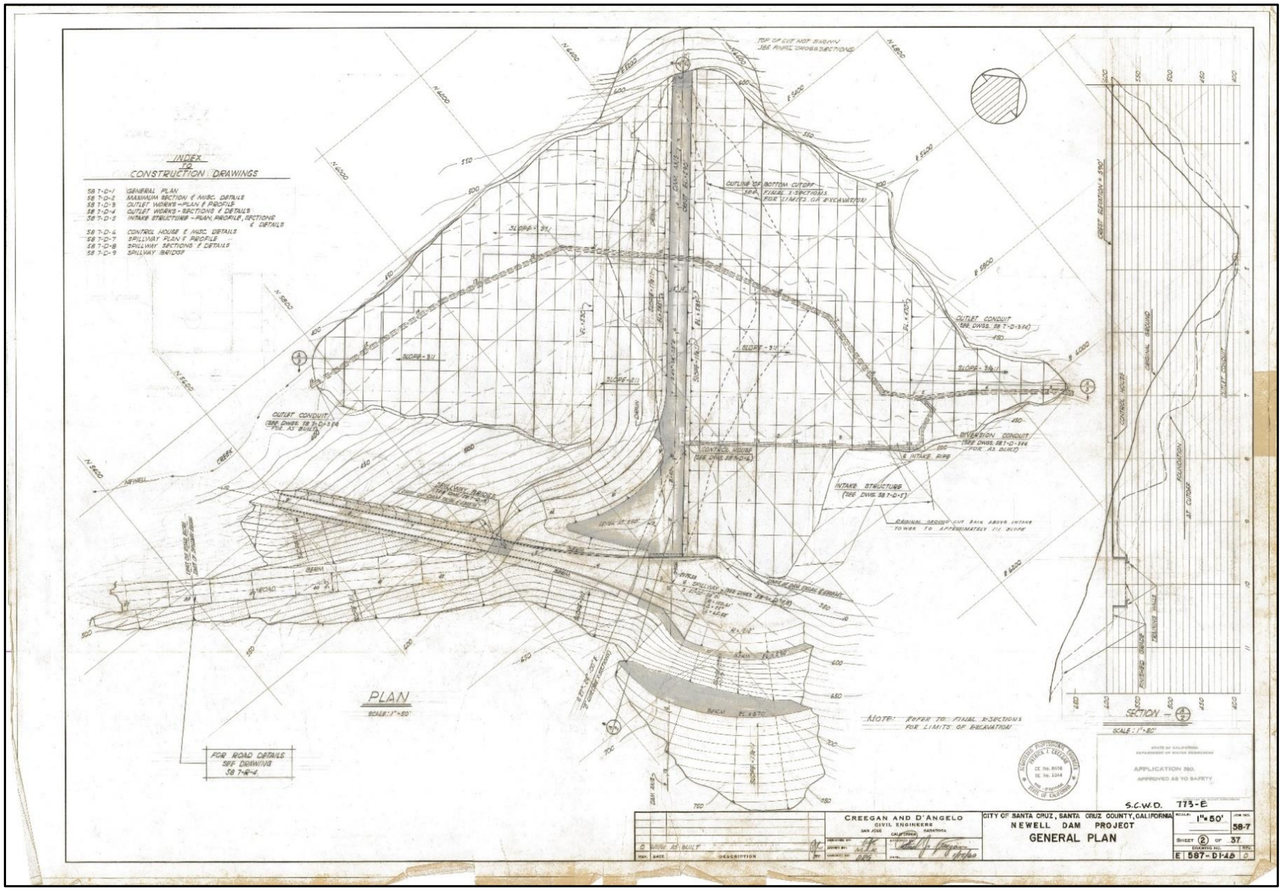

Figure 3-12: Newell Creek Diversion

Photo: Newell Creek Diversion from above left bank downstream looking upstream

Felton Surface Water Diversion at San Lorenzo River

The Felton Diversion is located on the San Lorenzo River just downstream of the Zayante Creek confluence and approximately five miles upstream of the Tait Street Diversion on the San Lorenzo River (See Figure 3-1: Water System map). The Felton Diversion consists of a three-foot-high concrete weir spanning the stream channel with an inflatable rubber dam attached to the top of the weir structure. The rubber dam is inflated after flushing flows (approximately >100 cfs) have occurred and antecedent precipitation is sufficient to keep river flows elevated above 40 cfs for a several weeks. When flows approach approximately 40 cfs, the dam is typically deflated. The dam is automatically deflated during channel-forming flows to avoid infrastructure damage and exacerbating upstream flood hazards. When not in operation, the dam is completely deflated and lays flat against the riverbed. The dam is eight feet high when fully inflated. A pump station is located on the west bank adjacent to the dam and weir structure. Water from the diversion is diverted into a screened intake sump and transferred via a pipeline to the Felton Booster Station located near Graham Hill Road. The flows are transferred via the Felton Booster Station to Loch Lomond Reservoir for storage and later use.

The City has appropriative water rights at the Felton Diversion. The Felton Diversion is implemented by two permits (Nos. 16123 and 16601) which allow a maximum annual diversion of 3,000-acre feet to Loch Lomond Reservoir for storage and later use.

The Felton Diversion operates according to two Memorandum of Agreements (MOAs) signed with the CDFW (Agreement Between City of Santa Cruz and CDFW for Streamflow Maintenance and Operation of Fishway at Felton Diversion Project on San Lorenzo River for the Protection and Preservation of the Fish and Wildlife Resources, 1971 (Appendix 4: *Felton Diversion Memoranda of Agreement*) and Memorandum of Agreement between CDFW and the City of Santa Cruz Regarding Operation of the Felton Water Diversion, 1998 (Appendix 4: *Felton Diversion Memoranda of Agreement*). These MOAs primarily focus on preservation of downstream instream flows and fish passage through the diversion. The maximum rate of withdrawal for October 1 to May 31 is 20 cfs with a minimum bypass flow of 25 cfs for October and 20 cfs for the period November 1 through May 31. In September, the diversion rate is 7.8 cfs with a 10 cfs bypass requirement – though diversion in September is often impossible and unnecessary. The Felton Diversion does not operate June through August. Under the HCP, the City will continue to operate the Felton Diversion in accordance with the existing MOAs. See Appendix 4: *Felton Diversion Memoranda of Agreement*.

Future rehabilitation of the Felton Diversion will include pump, screen, and ladder improvements, though no pumping capacity increases are currently planned. See Section 6.2.1 for a discussion of water supply reliability – related future water rights changes associated with this facility. The hydraulic performance evaluations conducted by Entrix in 2001 and Borcalli and Associates in 2006 indicate approach and sweeping velocities at the two existing screen panels are virtually all within criteria for continuously cleaned screens. Accordingly, no suggestions are warranted for improvements to the fish screen arrangement from the standpoint of impingement velocities, velocity distribution, or exposure duration. However, the existing screen material requires replacement with either wedge wire with a 1.75 mm slot width or perforated plate with 3/32" diameter perforations to account for the presence of fry-sized salmonids within the water course. To keep the fish screens operating at optimum efficiency and since no means are currently employed at the site for continuous screen cleaning, a mechanical traveling brush system is also recommended to minimize screen clogging. Additionally, provision of a continuous bypass route for escapement of juvenile out-migrants would reduce effects of this diversion on special-status fisheries. The existing intake currently maintains connectivity between the forebay and tailwater pool only when the MOA dictates the existing sluice gate be opened at the terminal end of the structure. Under most operating conditions the intake structure functions as a "blind alley" which requires fish that have entered the intake to return upstream past the fish screen panels in order to exit the structure and locate an alternative downstream migration route. These improvements will be included in future rehabilitation of this facility associated with implementation of the water rights modifications included in the proposed Santa Cruz Water Rights Project (as described in Section 6.2.1). See Figure 3-13: Preliminary Future Felton Diversion Plan Profile, Figure 3-14: Preliminary Future Felton Diversion Plan Profile, and Figure 3-15: Felton Diversion photo.

Figure 3-13: Preliminary Future Felton Diversion Plan Profile

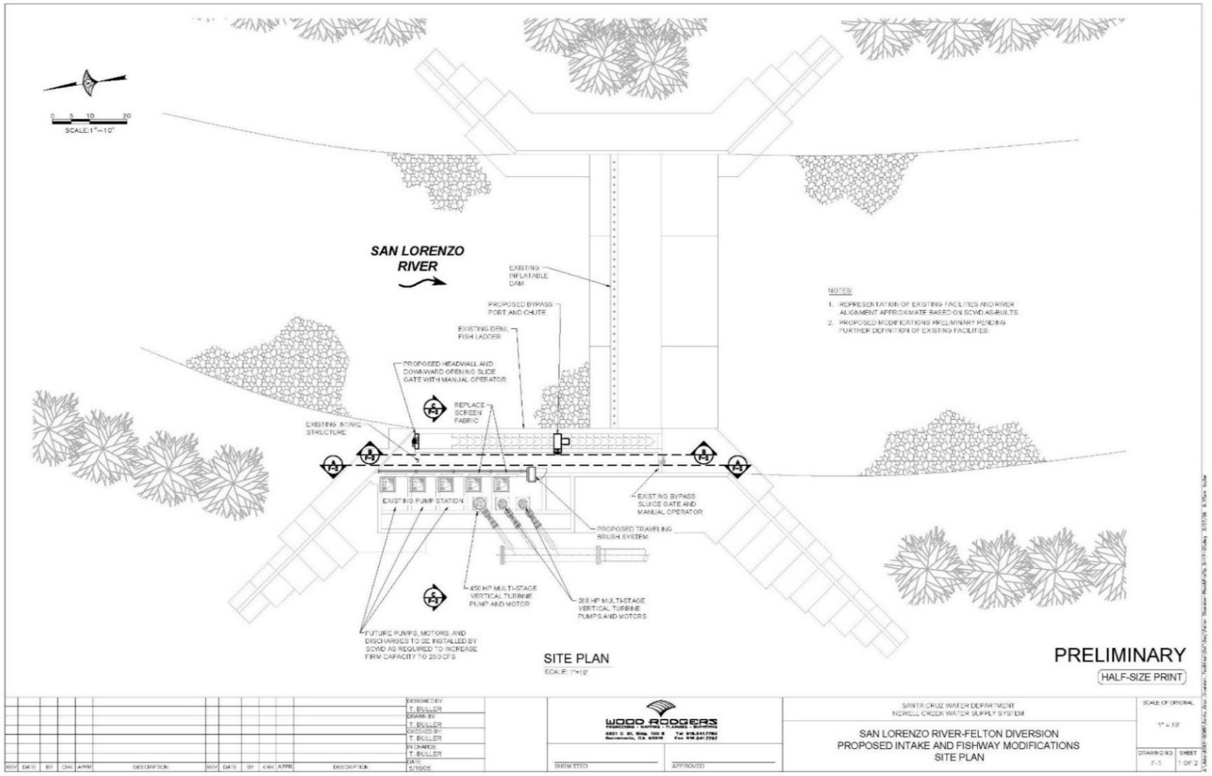

Figure 3-14: Preliminary Future Felton Diversion Plan Profile

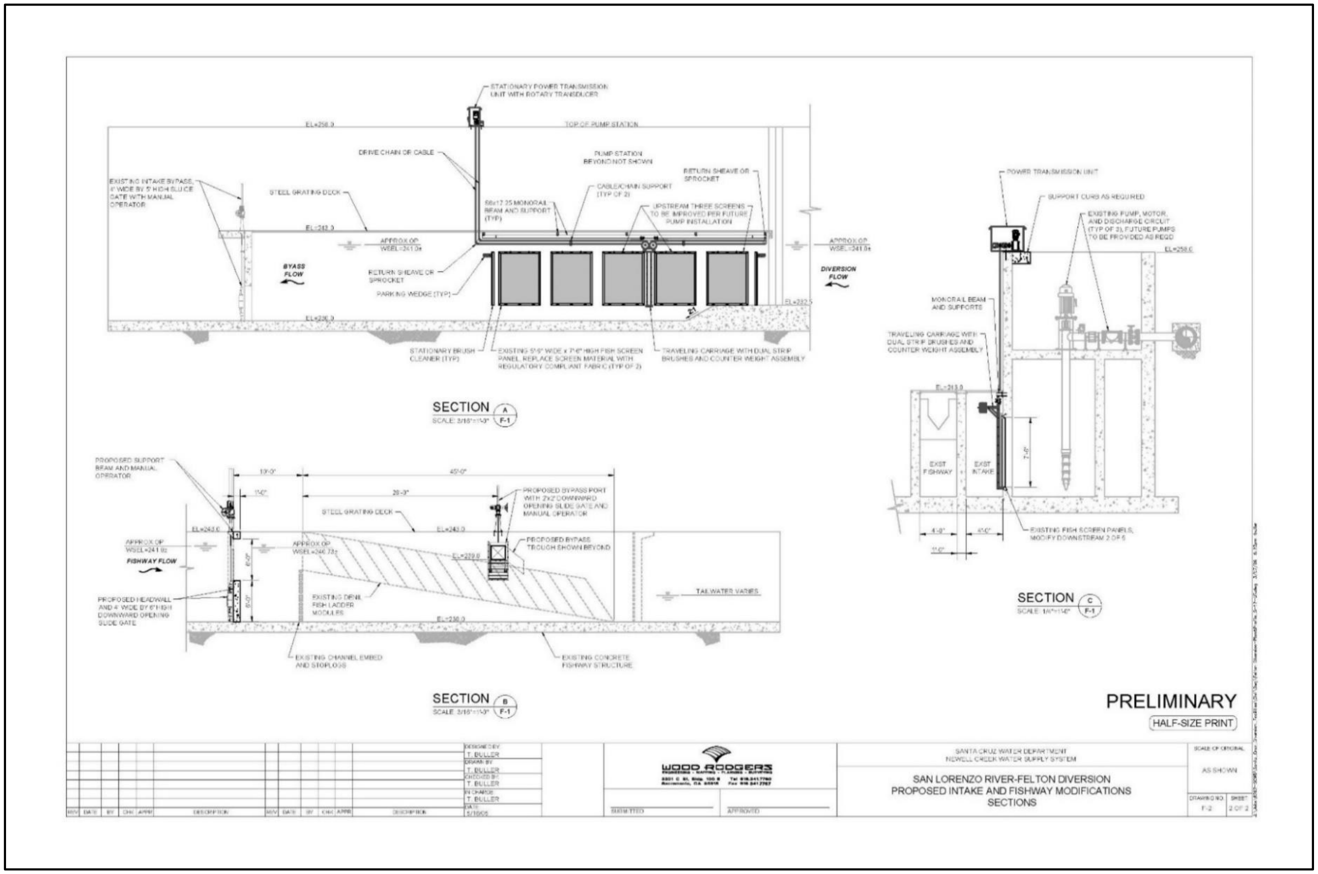

Figure 3-15: Felton Diversion

Photo: Felton Diversion from left bank downstream looking across the channel

Tait Street Diversion and Wells[39]

The Tait Street Diversion is located approximately 1 mile north of Highway One on the west bank of the San Lorenzo River at the terminus of Crossing Street (*aka Tait Street*) (See Figure 3-1: Water System map). The diversion consists of a low diversion dam (approximately three feet in height) that spans the width of the river and a concrete intake structure. The Tait Street Diversion also includes several wells located on the east side of the river. The wells range in depth from 71 - 89 feet and are considered to be under the influence of surface water.

Current water rights at the Tait Street Diversion and Wells consist of two licenses (Nos. 1553 and 7200) for appropriative rights to a maximum combined diversion rate of 12.2 cfs year-round. There is no annual limit specified in the licenses nor are there downstream release requirements included in the licenses. The future diversion rate at this facility may increase to up to 27.85 cfs during high winter flow periods to support water supply reliability. See Section 6.2.1 for a discussion of water supply reliability – related future water rights changes associated with this facility. Water is diverted on a continuous basis, interrupted only for excessive turbidity due to storms, short term water quality degradation resulting from spills of potentially harmful materials, mechanical breakdown, or routine maintenance.

Surface water is directed to the intake by the low diversion dam. The intake structure is concrete, built parallel to the stream bank, and extends downstream from the dam. The intake structure is protected by a debris rack and the downstream end of the intake is fitted with a hydraulic slide gate that is normally open during high flows and closed during low flows. This ensures the intake screens remain submerged and also maintains a continuous flow of water through the intake back into the river. A pipeline carries water from the intake to the pumping clearwell, where three vertical turbine pumps pump the water to the Graham Hill Water Treatment Plant. The diversion does not currently have a fish ladder, however fish passage and screening improvements are being considered currently in the context of overall facility rehabilitation. All improvements will be informed by discussion with CDFW and NMFS and will abide by NMFS criteria as applicable.

The wells operate in the summer and fall to reduce surface water diversion effects on instream flows and during the winter to improve the quality of unfinished/raw water coming from the facility. Water is delivered to the pumping clear well on the west side of the river. The groundwater is then pumped into a common transmission line to the Graham Hill Water Treatment Plant. These wells account for about five percent of total volume of water diverted at this San Lorenzo River facility and less than three

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[39] This facility is generally called "Tait Street Diversion" but is also called "San Lorenzo River Diversion" on occasion.

percent of total annual production from all water sources. See Figure 3-16: Tait Street Diversion Schematic, Figure 3-17: Tait Street Well #1b photo, and Figure 3-18: Tait Street Diversion photo.

Figure 3-16: Tait Street Diversion Schematic

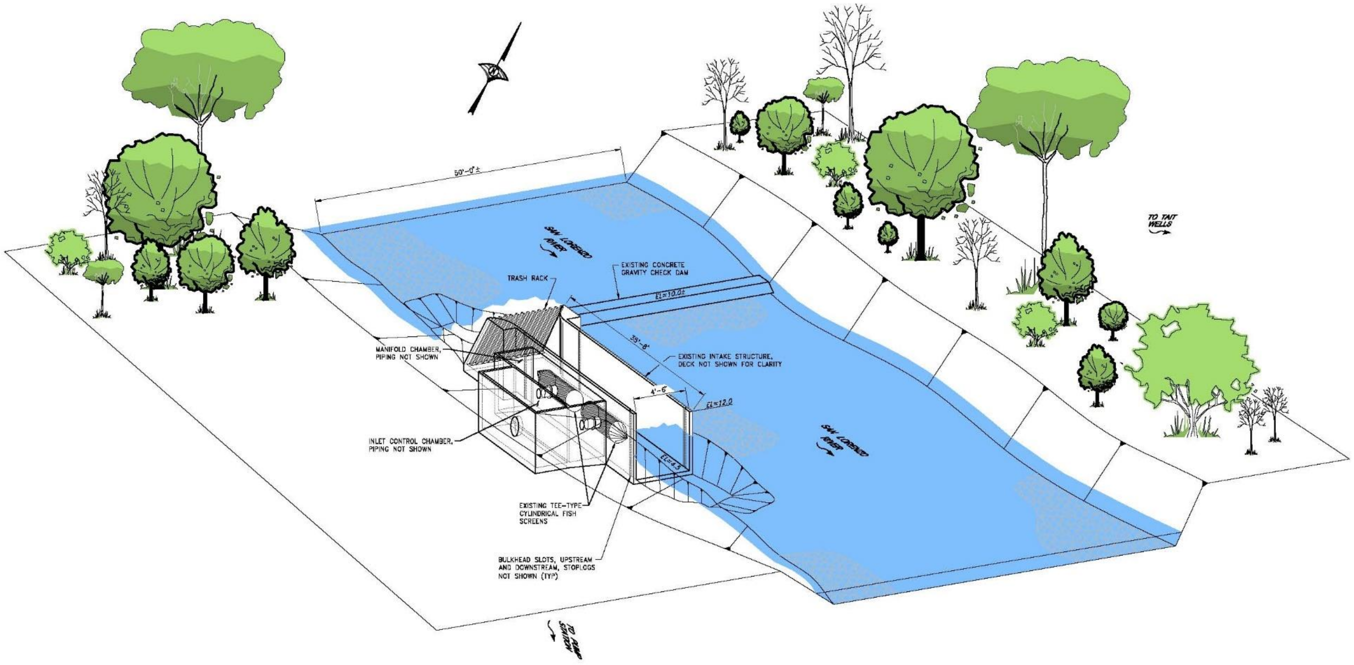

Figure 3-17: Tait Street Well #1b

Photo: Tait Well #1b

Figure 3-18:Tait Street Diversion

Photo: Tait Street Diversion from left bank downstream looking across the channel

3.3.2 Reservoir Operations

Reservoir operations focus on activities that occur at the Loch Lomond Reservoir to provide a safe, reliable source of water for water customers. The activities are required by either the California Division of Dam Safety or the California Safe Drinking Water Act through the California Department of Health and Safety. Covered activities include reservoir water quality treatment and dam facility maintenance.

<u>Chemical Algaecide Treatment of Reservoir</u>

Loch Lomond Reservoir is a lacustrine environment and although not nutrient enriched, nevertheless annually experiences blue green algal blooms during the late spring-early fall months due to available nutrients, warm water temperatures, and abundant sunlight. When algal blooms do occur or are predicted to occur, chemical algaecide applications are made to the Loch Lomond Reservoir to protect against degradation of beneficial uses (e.g., objectionable taste and odor, production of disinfection by-product precursors and cyanotoxins, and oxygen depletion and subsequent fish kills). Algaecides used include copper carbonate or hydrogen peroxide. These algaecide applications are regulated by a National Pollutant Discharge Elimination System (NPDES) permit issued by the State Water Resources Control Board and implementation is described in the City's Aquatic Pesticide Application Plan. See Appendix 6: *Loch Lomond Aquatic Pesticide Application Plan and SWRCB Aquatic Pesticide General Permit*.

The Water Department conducts weekly water quality sampling at one station in the lake to assess overall algae population. Species present at the surface and at the levels of the two upper water intakes (elevations 550 and 530 feet respectively) are identified and counted and may be analyzed for chlorophyll. When known nuisance species are on the increase (i.e., *Anabaena, Aphanizomenon, etc.*), sampling is increased to daily and when the counts and chlorophyll values indicate a bloom appears certain, algaecide is applied.

The applications generally occur once or twice between the months of April through September. Annual frequency of applications ranges from as low as 1 time/year to as high as 5x/year. A private applicator or City staff under the direction of a licensed applicator may conduct the application. The lake shallows are surveyed by staff prior to application to identify any Western Pond Turtle, fish breeding or early fish life stage presence. If located, these areas are not treated or treated at a reduced concentration, per direction of the City's SWRCB NPDES permit for aquatic algaecide application. The treatment area is tested the day after treatment to confirm that no high levels of algaecide are present. Hydrogen peroxide is not persistent in the environment and is not discharged to Newell Creek below the dam, so monitoring is primarily focused on copper carbonate. Weekly copper monitoring is continued at the surface and 20-foot depth intervals until copper returns to near pre-treatment levels. The fish release below the dam into Newell Creek is also sampled weekly. Upstream and downstream, copper sampling may occur on a regional scale to provide context for the copper dynamics observed in the reservoir and feedback on permit compliance. The Central Coast Regional Water Quality Control Board Basin Plan objective for copper is 30 ug/l.[40] The downstream permitted limit of copper discharge is 13 ug/l under the California Toxics Rule,[41] though temporary exceedances of this value – if below the Basin Plan objective – are allowed under the SWRCB NPDES permit during the algaecide application season of April - September. Copper may be discharged for weeks or months at low levels

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[40] https://www.waterboards.ca.gov/centralcoast/publications_forms/publications/basin_plan/docs/2019_basin_plan_r3_complete_webaccess.pdf

[41] Future downstream permitted limits may be contingent on a site-specific Biotic Ligand Model rather than the California Toxics Rule

(< 13 ug/l) subsequent to a treatment. The discharge point is 0.7 miles upstream of the typical limit of anadromy and 1725 feet upstream of the confluence with an unnamed tributary which contributes significant flow to Newell Creek (and thereby dilution of the discharge). Copper levels observed at the barrier 0.7 miles below the dam are an average of 3.7 ug/l while data collected further downstream at the Glen Arbor Bridge shows an average value of 2.1 ug/l.

Testing Deluge and Gate Valves

Testing of the deluge and gate valves on the dam involves opening the deluge valve located on the downstream side of the dam face approximately 0.7 miles above the typical limit of anadromy and seeing water released and then closing the valve and not seeing water released. Additionally, the five intake gates in the lake on the upstream side of the dam face are closed and the pipeline in the dam is drained to determine that the gates are holding as determined by no water passing through them. This testing is done at the direction of the Division of Safety of Dams (DSOD) and occurs in both the dry season and wet season in an alternating fashion annually (i.e. one year will be done in the dry season and the next year will be done in the wet season). The testing typically occurs for a period of several hours at a rate of discharge of approximately 5-10 cfs during the testing period. Future DSOD-required testing may involve a higher rate of discharge but will be coordinated with higher flows to mitigate potential effects on instream habitat and water quality. The procedures can result in the discharge of approximately 100,000 gallons of moderate to low oxygen (1-6 parts per million (ppm) at a range of 9-17 C˚ approximately) water discharged to Newell Creek immediately below the dam when done in the dry season. During the wet season when the reservoir is fully mixed, discharge water is well-oxygenated and <14 C˚.

Woody Debris Removal on Reservoir Face

Woody debris removal is conducted annually in the late fall when the fire hazard is low (after rains and during burn season). The work requires approximately 4-10 days to complete. A log boom is used to remove the wood at the top of the spillway and a boat, rubber-tired skidder and hand crews are used to remove the woody debris from the inside of the dam face. Wood removed is typically less than 10” in diameter and 8’ long. Average total volume of wood removed is approximately 10 cubic yards, annually. Bigger pieces are set aside for later use in instream restoration projects. Heavy equipment is excluded from the dam face to minimize soil disturbance. The wood is then piled on the inside face of the dam, cut up with a chainsaw, and burned. Large woody debris pulled from the lake is retained in the wood lot below the dam for restoration projects if possible.

3.4 Water System Operation and Maintenance

Water system operation and maintenance includes activities conducted to maintain operations of the water diversions and water transmission lines, and associated diversion features such as fish screens and fish ladders.

These activities are covered under the HCP and include operation, rehabilitation, replacement, repair and maintenance of existing infrastructure and related facilities such as water measurement devices, scientific measuring devices, and water quality monitoring stations.

3.4.1 Water Diversion Sediment Management

Laguna, Reggiardo, and Majors Creek diversions on the North Coast are concrete impoundments that can collect sediment and debris during storm flows. Sediment management at these diversions primarily focuses on managing bedload and suspended sediment during storm flows with an attempt to mimic the natural hydrograph as much as possible. Each diversion has a dual slide gate valve mechanism in the dam face. The upper gate is opened during the ascending limbs of sediment-transporting storms (generally speaking, storms that are predicted by the National Weather Service (NWS) to result in 2” of precipitation in 24 hours or result in turbidity over 25 NTU) if it is free of sediment prior to the storms, and then closed on the receding limb of the storm or following storms if several storms follow in succession. The receding limb is identified either onsite with staff plates, or through real-time dataloggers installed at the Laguna and Liddell diversions, with these gages serving as a surrogate for Majors and Reggiardo Creek – which have no real time communications. If sediment does collect behind the impoundments, the impoundments are dredged. Dredging is conducted during the dry season (August – October) if possible, but always during low flows with heavy equipment and/or hand tools and the material is removed from the site as soon as possible. If excavation is necessary, the volume of sediment involved will range from 5-10 cubic yards per event up to 1-3x/year. The instream work area is limited to the area immediately adjacent to the intake screens and is isolated from the wetted channel with sandbag diversions, turbidity curtains or related materials. Fish removal in the work area is performed by an agency-approved biologist if necessary. The work area typically involves less than 50 linear feet of stream immediately adjacent to the intakes.

The Laguna Creek and Majors Creek diversions will be rehabilitated in order to allow more natural passage of sediment, avoid instream maintenance work and more effective implementation of instream bypass flows in the future and this project is covered under the HCP. The rehabilitation will make part of the dam face movable or otherwise improved with wedge wire screens so that during stormflows sediment transport occurs in an unimpeded fashion and impacts associated with dredging will be reduced in the future. It is likely that the Reggiardo Diversion will be removed in the future.

Although the Liddell Spring Diversion is located on top of a natural spring and is not an in-channel diversion structure, sediment can still accumulate in the spring box during large storm events. When needed (up to 3x annually), the City removes up to 3 yards of sediment with hand tools, suction pumps or vacuum equipment and removes the material from the site immediately or after brief temporary storage. As previously mentioned, sediment is also allowed to “meter out” continuously by leaving the drain valve slightly ajar – thereby preventing accumulation in the spring box and providing an informal small instream flow to an unnamed, non-fish bearing tributary to the east branch of Liddell Creek.

3.4.2 Fish Ladder and Screen Maintenance

The only City facility with a fish ladder is the Felton Diversion on the San Lorenzo River.[42] The ladder is a standard removable Denil fish ladder located at the western side of the weir that operates when the dam is inflated. The ladder consists of a fishway with a removable fish trap. The fish ladder is operated according to the MOA described in Section 3.3.1. The ladder is approximately 60’ long x 3.5’ wide and has a floor slope of 6:1. The ladder is inspected 2-3 times per week and manually cleaned and cleared of debris as needed. A log boom at the upstream end of the ladder reduces accumulation of debris in the ladder, but 1-3 times per winter up to a cubic yard of sediment and woody material needs to be removed from the ladder. Debris removed from the ladder is removed from the site or is mobilized downstream during high flow events. Future improvement of the ladder includes installation of improved outmigration features. The fish screens at all the diversions are inspected regularly and cleaned by hand of any debris. The San Lorenzo River at the Tait Street Diversion has two Johnson-type well screens that are cleaned by compressed air back flush at intervals ranging from 10 minutes to 2 hours when the diversion is on. The screens are protected by a debris rack that is inspected daily and manually cleaned as needed. Future screening improvements at diversions described in Section 3.3.1 will reduce maintenance needs in the future.

3.4.3 Pipeline Operations

Adequate operation of the water transmission lines requires system flushing and repairs and specialized operations, including pumping well return to prevent sand accumulation and valve blow-offs to prevent breaks in the transmission lines.

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[42] Fish ladder maintenance procedures for a future, rehabilitated Tait Street Diversion are expected to involve similar activities.

Conveyance Pipeline System Inspections and Repairs

The City's two major unfinished water (raw, unchlorinated water) conveyance lines are the Newell Creek Conveyance Pipeline and the North Coast Conveyance Pipeline. These lines are 9.57 and 9.66 miles long, respectively. See Figure 3-1: City of Santa Cruz Water System map. Additionally, the City has 6.8 miles of finished (chlorinated) water line that runs from the City limits west to North Coast customers. These lines are part of the City's existing infrastructure and are critical to safe and reliable transmission of water to customers. While the Newell Creek pipeline is located primarily in upland areas, it does cross several streams and run adjacent to both Newell Creek below Loch Lomond Reservoir and the mainstem San Lorenzo River from Ben Lomond to Henry Cowell State Park. Similarly, the North Coast pipeline crosses several streams between Bonny Doon and the west side of the City. Pipeline routes are regularly inspected for leaks and pipeline rights of way are maintained to allow for inspection of the pipeline. Usually an eight-foot swath of predominantly upland vegetation is mowed to allow inspection of rights of way in rural areas. Clearing in riparian corridors is done by hand on an as-needed, infrequent basis. Inspection occurs in the fall and spring of each year, and when decreases in flow indicate a leak. Inspection includes walking the route by foot or traveling the route with an all-terrain vehicle.

Pipeline repairs are conducted on an as-needed basis. Repairs may result from damage to the pipeline through natural causes (earthquakes, landslides, etc.) or through deterioration of infrastructure over time. Staging areas for repair projects may be required depending on the location of the repair and may include areas for storage of construction materials and construction equipment. Pipeline repairs may also require trenching and construction of temporary access ways. Standard avoidance and minimization measures are employed for pipeline repairs to reduce or eliminate instream effects from this work, as described in Chapter 4, *Conservation Strategy*.

The approximately 3.28-mile sanitary landfill leachate line which runs from the solid waste recovery center on Dimeo Lane to the City's wastewater treatment plant near Neary Lagoon has similar maintenance needs. While it is located in the proximity of only one known anadromous salmonid stream (Wilder Creek), standard avoidance and minimization measures are also employed for this work to reduce or eliminate instream effects, as described in Chapter 4, *Conservation Strategy*.

Finished Water Pipeline System Flushing and Repairs

The finished water pipeline distribution and conveyance system includes approximately 263 miles of pipeline in the water distribution area which includes the entire City, as well as a portion of unincorporated Santa Cruz County and a small portion of the City of Capitola. These pipes are generally located within streets and may include stream crossings or be located adjacent to water bodies. The distribution line must be kept clean of bacteria and contaminants and requires testing for hydrant capacity as well as pipeline repairs. See Figure 3-1: City of Santa Cruz Water System map.

Regular maintenance activities that occur on the distribution system may include the flushing of the line for fire hydrant testing; repair of main breaks; sediment removal; taste and odor control; control of color, high turbidity, low chlorine residuals, or bacterial growth; corrosion control; or response to customer complaints. Flushing is a water quality practice required by the California State Water Resources Control Board – Division of Drinking Water under the Safe Drinking Water Act. These maintenance activities occur year-round on various parts of the distribution system according to management priorities. Most repairs do not involve sensitive habitat, but those that do include standard avoidance and minimization measures to reduce or eliminate instream effects from this work, as described in Chapter 4, *Conservation Strategy.*

Pumping Well Return to the San Lorenzo River

At high and moderate flows, sand accumulates in the pumping clearwell of the San Lorenzo Wells located at the Tait Street Diversion (aka Crossing Street) adjacent to the San Lorenzo River just upstream of Highway 1. To reduce damage to equipment and prevent re-deposition in the Graham Hill Water Treatment Plant, sump pumps remove sand from the clear well, pump it to an adjacent decanting basin located in the parking lot of the Coast Pump Station and ultimately returns decanted water to the river immediately downstream through a riparian vegetation buffer without any elevation in turbidity. This activity typically occurs routinely in the winter and spring when flows are elevated and sediment is being transported by the river. The discharge from the decanting basin through the riparian corridor to the river results in no change in receiving water quality or changes in habitat.

North Coast Valve Blow Off to the San Lorenzo River

The North Coast Pipeline delivers unfinished/raw (non-chlorinated) water from the North Coast sources to the Coast Pump Station, which ultimately delivers water to the Graham Hill Treatment Plant. At the Coast Pump Station (at Tait Street) water from the pipeline is discharged to the San Lorenzo River when pressure within the pipeline threatens to rupture the line. The discharge prevents pressure from blowing out the North Coast Pipeline (subsequently preventing environmental impacts related to such blowouts) when sources are changed and during situations such as emergencies. Recently installed pressure relief valves minimize the potential for this occurrence.

The North Coast Pipeline Blow Off may occur year-round but only when the North Coast sources are on. This activity occurs rarely (less than 1 time annually) and only under special circumstances where dewatering the main elsewhere is not possible. The approximate amount of discharge during this operation ranges from 5-10 cfs and could persist for approximately 1-4 hours. The water is discharged over rip rap to the San Lorenzo River downstream of the intake located at the Coast Pump Station at Tait Street just upstream of Highway 1.

3.4.4 Dewatering of Creeks for Maintenance and Repairs

The City performs various types of instream work including, repair and maintenance of diversion facilities, sediment management, fish ladder and fish screen maintenance and repair, pipeline operations and maintenance, flood control and stormwater maintenance, vegetation management, and aquatic habitat management. During the course of these activities it is often necessary to dewater and otherwise disturb portions of stream channels. Dewatered stream reaches can range from approximately 20-200 feet and dewatering may occur for up to several weeks in any given year or not at all at 1-10 sites annually. In order to minimize effects of these activities on aquatic species, including protected species, the City captures aquatic species in the project area and relocates them to suitable habitat outside the project area. Additionally, other standard best practices are employed during dewatering such that effects on special-status fish species are limited to relocation. (Chapter 4).

3.5 Municipal Facility Operations and Maintenance

Municipal facility operations and maintenance activities include flood control maintenance, stormwater maintenance, emergency repairs and response, and vegetation management. These activities occur on City facilities and properties in the HCP Program Area. These activities include operation, rehabilitation, replacement, repair and maintenance of existing infrastructure and related facilities.

3.5.1 Flood Control Maintenance

Flood control maintenance is conducted to prevent flooding of city waterways and damage to public and private property. Flood control preventative activities are conducted in July through October on an as-needed basis. Emergency response during storms is conducted if damage to life, property, or public safety is imminent. Flood control maintenance includes debris/obstruction removal, sediment management/removal, and vegetation management. This work has historically been covered by Section 7 consultations due to the federal nexus with the U. S. Army Corps of Engineers (Corps). However, for the purposes of expediting permitting in the future and ensuring alignment between the diversity of City operations that affect the San Lorenzo River, Flood Control Maintenance is included as a Covered Activity in this HCP. Historic Section 7 consultations are provided for reference in Appendix 7: *Example Historic Flood Control Biological Opinions*.

Debris/Obstruction Removal

Debris/obstruction removal is necessary when a material is either deposited or washes downstream into a waterway and creates a hazard to property or infrastructure. Under these hazardous conditions, the City may conduct debris/obstruction removal, including log jam modification (cutting larger logs into smaller segments that may float downstream in larger flows, moving with cranes, etc.) and vegetation removal. Typically, these events happen 1-3 times in wet water years but may not be necessary during drier conditions. These wet conditions may occur anywhere from 10-50% of the time during the life of the permit (Shawn Chartrand, personal communication with Chris Berry, 2020). Volume of debris removed may range from 0-100s of cubic yards depending on the magnitude of storm events and upstream delivery of instream wood. These activities are only conducted in an emergency setting where property, life, or public safety is threatened and are done in consultation with NMFS, USFWS, and CDFW staff as appropriate. During and immediately after flood events, City staff inspects conditions at bridges, road culverts, diversions, pipelines, and other public infrastructure to ascertain whether threat to structures are imminent and will only take action if the structure or property is in immediate danger. Such work is typically overseen by environmental monitors and involves standard avoidance and minimization measures for streamside projects as described in Section 4.4.3.

Flood Control Sediment Management/Removal

The City takes a preventative approach to sediment management by implementing best management practices (BMPs) for stormwater facilities including vacuuming storm drains before the winter season and cleaning culverts, vaults, and ditches before winter, usually from August through October. See Section 4.4.4.2. Work is completed with mechanized equipment and hand tools. Mechanized equipment used for this work is kept outside of the wetted stream channel.

The San Lorenzo River Flood Control Project includes 18 drainage discharge structures which are maintained to prevent flood waters from backing into neighboring areas and to prevent spills from entering the river. See Figure 3-19, Figure 3-20, Figure 3-21, Figure 3-22, and Figure 3-23: City of Santa Cruz Stormwater System. Branciforte Creek also has several drainage discharge structures to be cleaned. The drainage discharge structures are cleaned on an annual or biannual basis. An excavator is used to remove sediment that has built up near the drainage gates. The amount of sediment averages 2 cubic yards per drainage discharge structure. The sediment is dewatered on site and the dried sediment is spread above ordinary high water on the riverbank to be removed by storm flows during the winter. See Figure 3-24: Flood Control Drainage Structure Example.

Sediment removal is only done as necessary to maintain and/or restore capacity of stormwater conveyance facilities or to prevent flood events. The nature and exact location of sediment removal in flood control areas is not know from season to season and is dependent on variation of winter storms flows, upper watershed events that produce sediment, and flood control monitoring data that documents aggraded areas that may not meet flood control standards established by the Corps. The flood control management prescriptions for the lower San Lorenzo River entail managing sediment outside of the wetted channel within the levees to facilitate transport of sediment and maintenance of adequate levee freeboard for flood control purposes. This work entails disking of dry sand bars during dry periods with heavy equipment as described in Table 3-1. This work is typically overseen by environmental monitors and involves standard avoidance and minimization measures for streamside projects as described in Section 4.4.3.

Sediment management in the Branciforte FCC is mostly limited to the lower reaches of the FCC from May Street to Water Street and is performed annually. The work occurs outside the wetted channel and is performed with a long-reach excavator from the top of the FCC. Approximately 270 cubic yards of sediment is removed with each maintenance event. The FCC is currently being evaluated for rehabilitation that will provide both additional flood control reliability as well as improved fish passage.

Figure 3-19: City of Santa Cruz Stormwater System

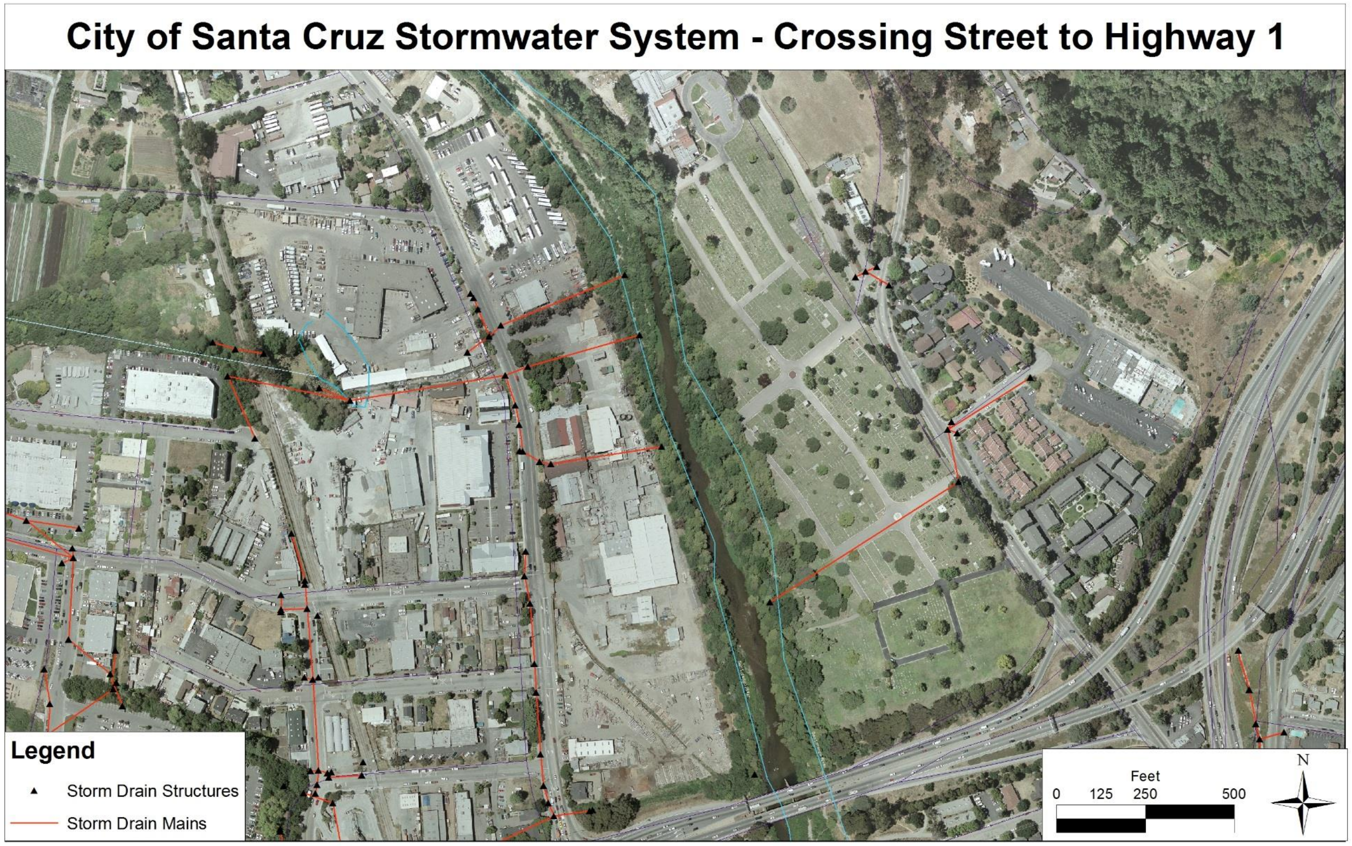


Figure 3-20: City of Santa Cruz Stormwater System

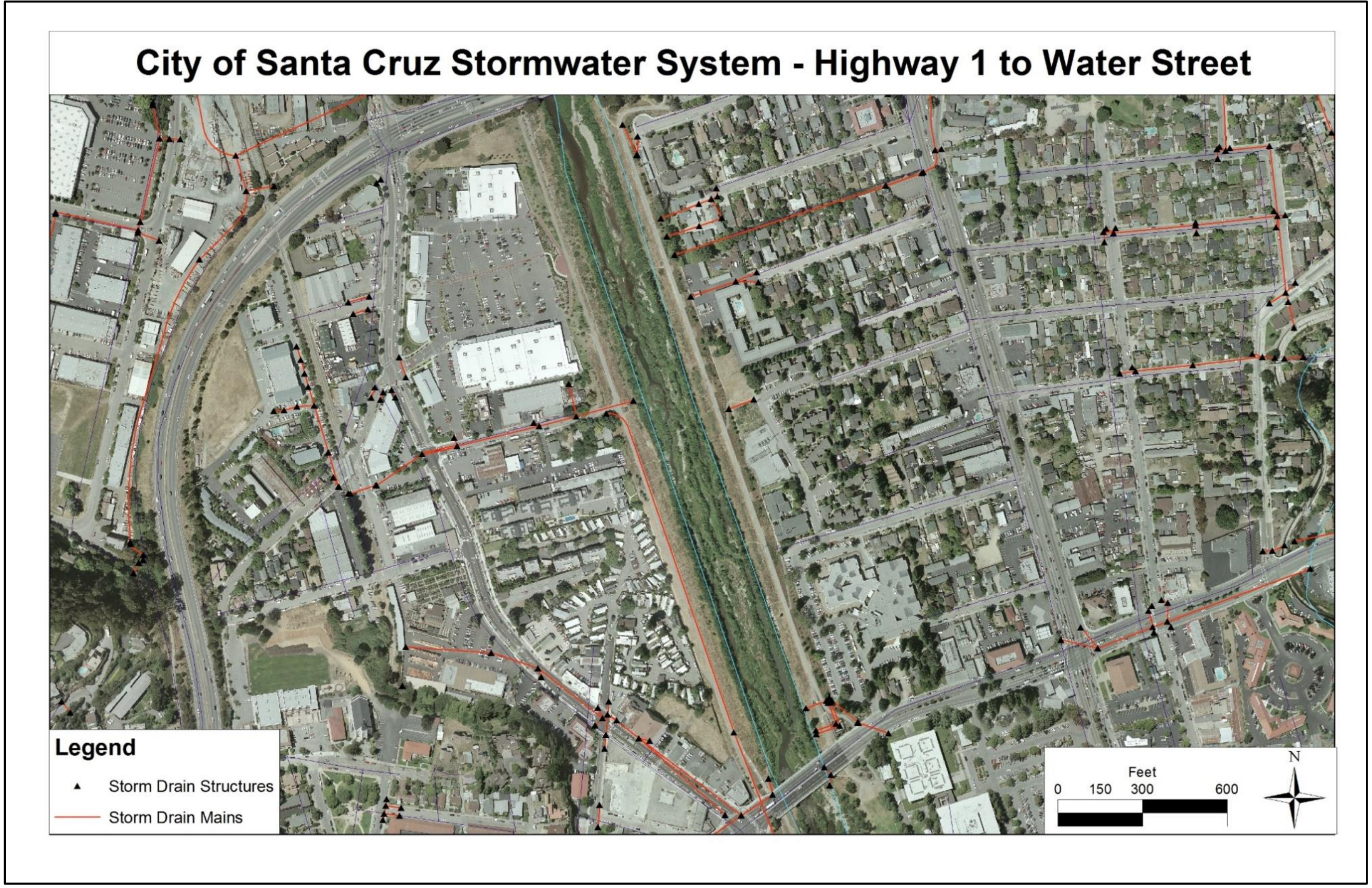


Figure 3-21: City of Santa Cruz Stormwater System

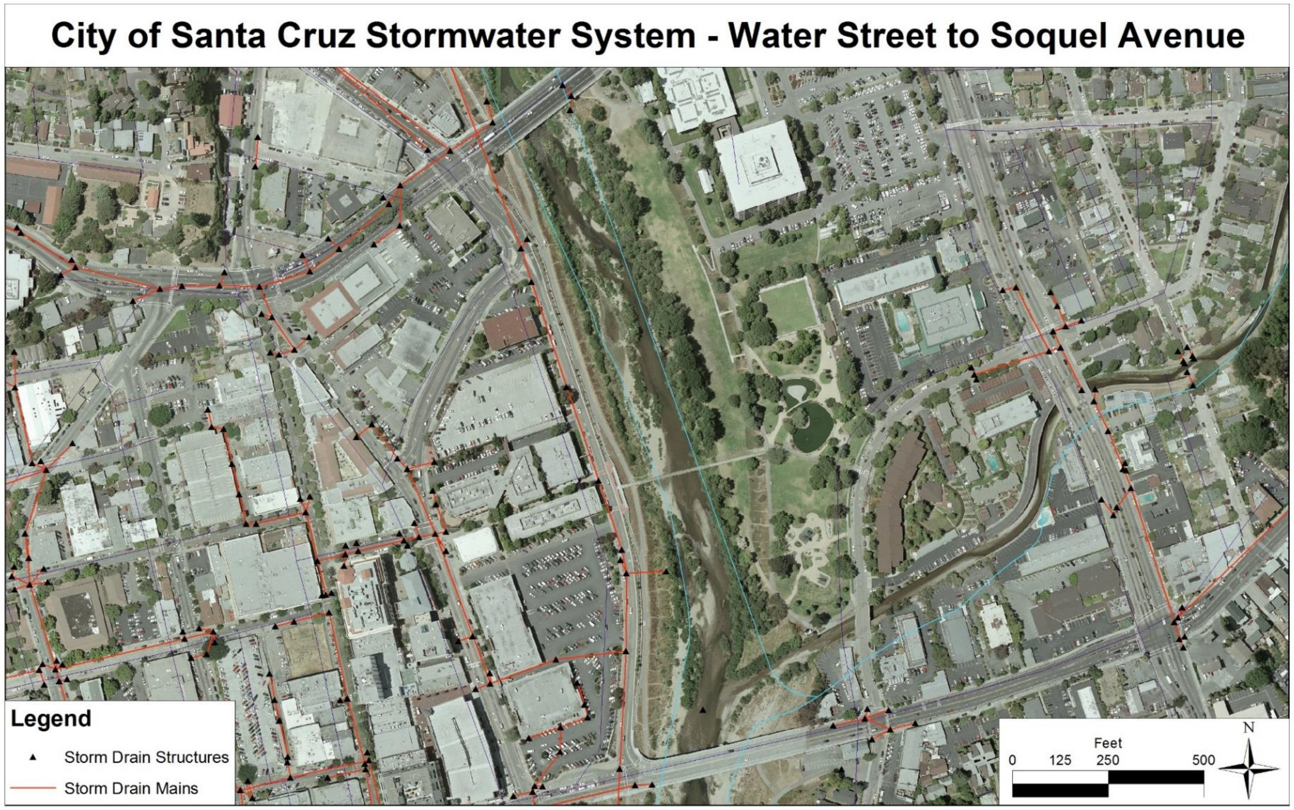


Figure 3-22: City of Santa Cruz Stormwater System

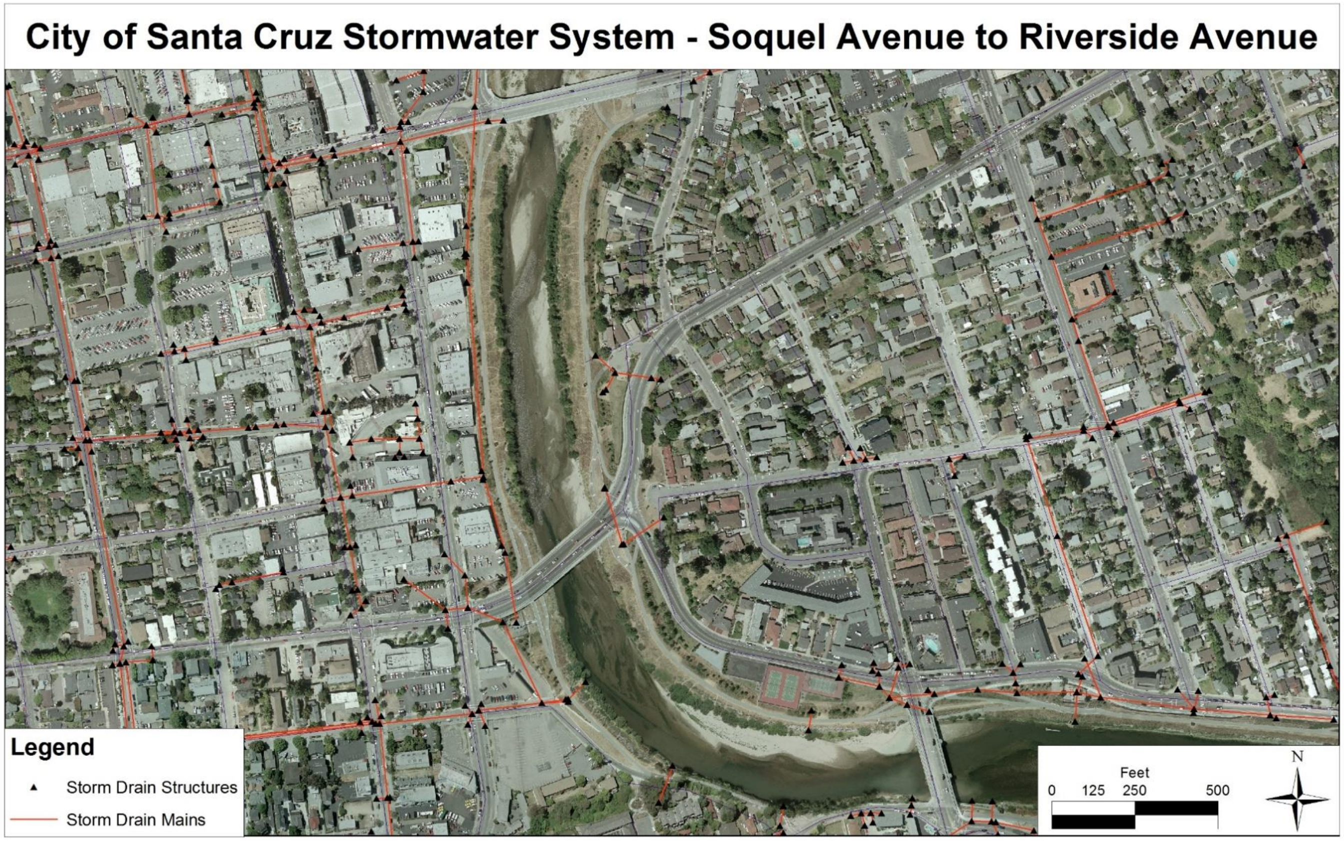


Figure 3-23: City of Santa Cruz Stormwater System

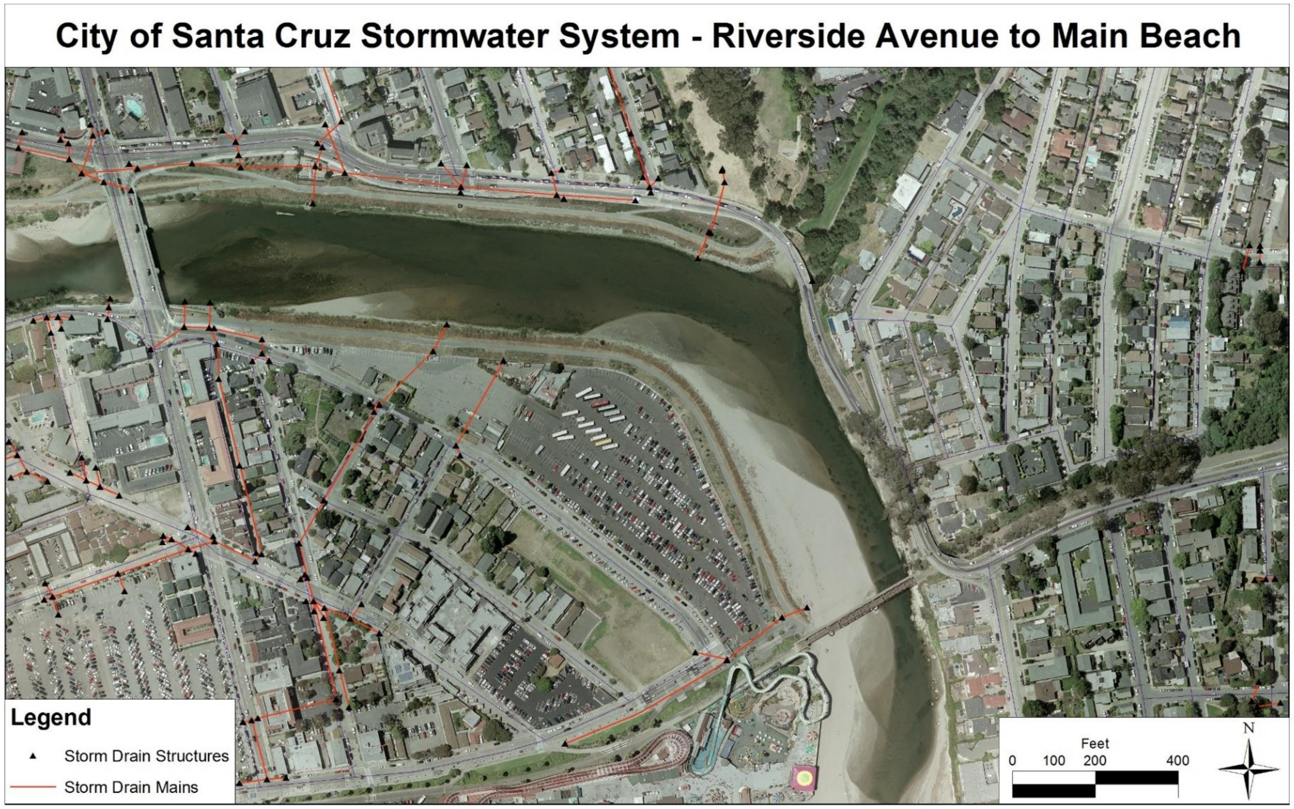
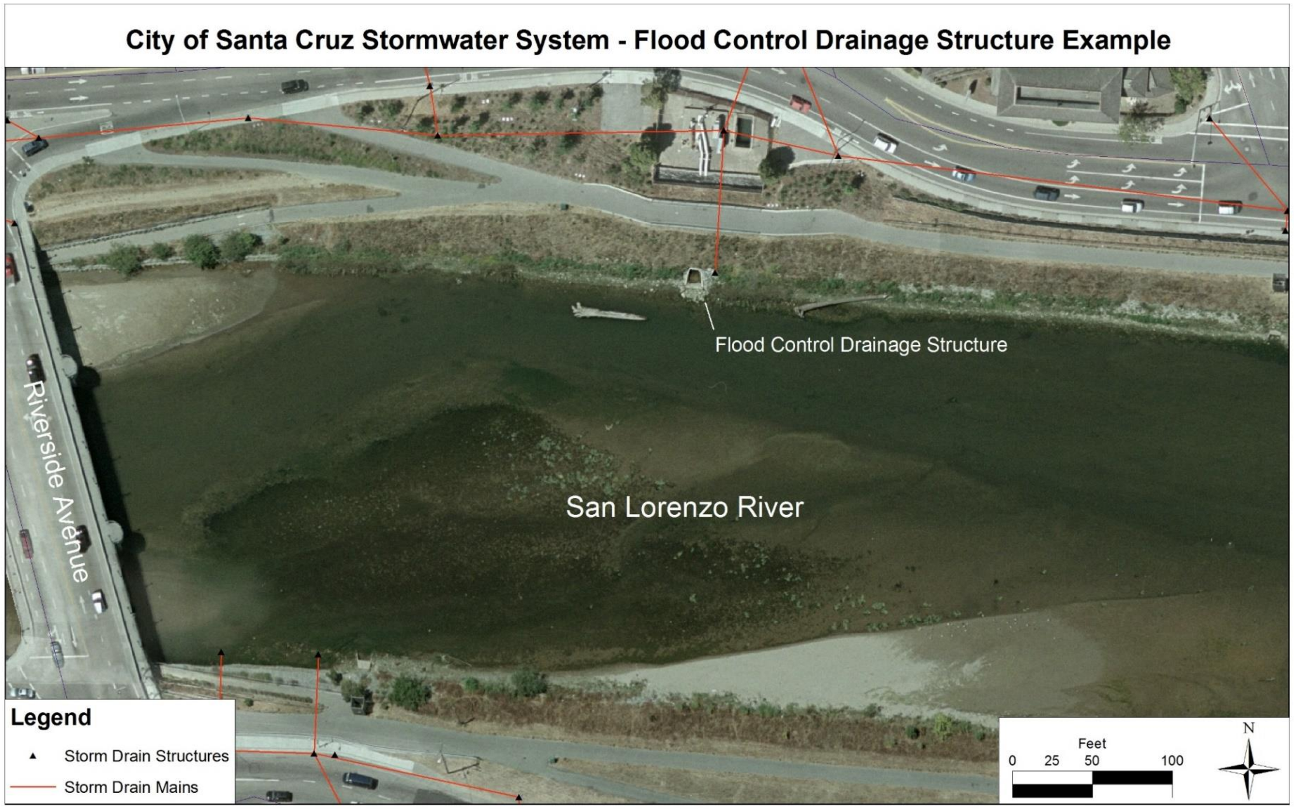


Figure 3-24: Flood Control Drainage Structure Example



Vegetation Management

Vegetation management focuses on trimming or removing riparian vegetation that may impede storm flows, result in bank erosion, or result in damage to property. In the majority of waterways other than the San Lorenzo River and Branciforte Creek FCCs, mature riparian trees are not removed, but riparian shrubs may be trimmed from ground level to 6-8 feet in height. Mature riparian trees are removed in the San Lorenzo FCC and Branciforte Creek FCC per maintenance requirements of the Corps to reduce roughness and ensure that the FCCs can pass design flows. Branciforte FCC maintenance typically occurs in the transitional reach below Water Street only and occurs as needed. Design criteria for the channel dictates that the channel be kept entirely clear of sediment and vegetation at all times, but resource limitations result in maintenance occurring infrequently (1 – 2x every 10 years). Cuttings are removed from the work area and recycled as green waste at the landfill or chipped and left on the outboard side of the FCCs. A 5 – 10-foot-wide buffer of vegetation is typically retained adjacent to the wetted channel. Work is generally conducted in late August and may last from a few days to a few weeks depending on the area. The vegetation management prescriptions are set out in Table 3-2. Such work is typically overseen by environmental monitors and involves standard avoidance and minimization measures for streamside projects as described in Section 4.4.3.

Table 3-1: Flood Control Sediment Management Prescriptions by San Lorenzo River Stream Reach*

Reach	Sediment Management Prescription	Frequency
Riverine Reach	Instream bars outside the wetted channel should be disked annually to loosen root materials and promote scour. Existing cross-channel scour areas should be encouraged through disking and manipulation of discarded root wads/vegetation material. Sediment removal areas should be defined by cross section and HEC-6 analysis and should avoid important salmonid habitat areas including riffles, pools, and runs.	1-3x Annually
Transitional Reach	Disking on the west bank should occur east of levee toe up until outside edge of 5-foot vegetation buffer. Existing cross-channel scour areas should be encouraged through disking and manipulation of discarded root wads/vegetation material.	As determined by cross-section monitoring. Will occur less frequently than every other year dependent on previous winter's sediment transport dynamics.
Estuarine Reach	Sediment management or removal is not necessary in this reach.	NA[43]

*See Figure 3-25: Urban San Lorenzo River Stream Reaches

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[43] This reach typically meets FCC design criteria without maintenance and sediment management is not currently proposed as a Covered Activity.

Table 3-2: Vegetation Management Prescriptions by Stream Reach*

Reach	Vegetation Management Prescription	Frequency
Bankfull Channel Area **Instream Channel Bed**	Remove riparian vegetation that exceeds accepted Corps Manning's "n" roughness coefficient for the FCC[44]. A 5-foot edge of stream buffer area should be maintained on either side of the wetted edge.	1x Annually
Riverine Reach	Allow 10-foot-wide strip of willow and alder along toe of levee. Willows allowed to grow to 3" diameter at breast height (dbh). Alders allowed to grow to 6" dbh. The lower limbs of the alder trees should be trimmed. The willows should be thinned to favor providing overhanging cover to the low flow channel. Maintain a 5-foot buffer along wetted edges of channel, but thin groves and limb up trees. Remove any trees in 5-foot buffer area that are greater than 6" dbh.	1x Annually
Transitional Reach	A 10-foot-wide strip of woody riparian vegetation and tules and cattails should be maintained on the west bank. The east bank should be maintained to keep trees overhanging water. Trees or branches that fall in the water should be assessed for cutting into smaller pieces and may be removed entirely if they cause an immediate safety hazard. Sandbars should be maintained to allow volunteer groves to establish but remove all trees greater than 6 " dbh.	1x Annually
Estuarine Reach	A 5-foot-wide strip of willow, cattail and tule should be maintained at the levee toe. Willows should have stem diameter of no greater than 0.5 inches and be limbed up and periodically thinned to create defined groves.	1x Annually

*See Figure 3-25: Urban San Lorenzo River Stream Reaches

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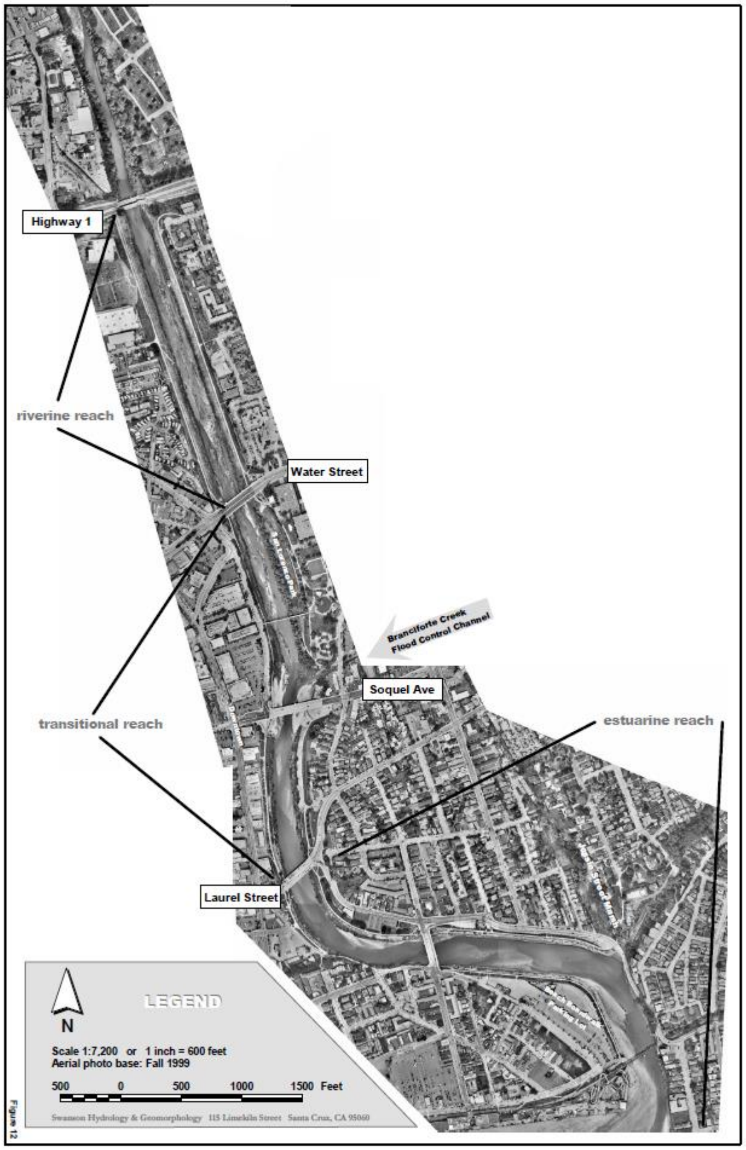
[44] Roughness coefficient targets can vary by stream reach and change depending on channel morphology dynamics with an overall goal of maintaining flood capacity for (at minimum) 100-year events.

Figure 3-25: Urban San Lorenzo River Stream Reaches



3.5.2 Stormwater Maintenance

Stormwater maintenance is conducted on the City's stormwater conveyance system and at the sanitary landfill. The City has an adopted Stormwater Management Program and has fulfilled the requirements for the NPDES Phase II General Permit for Discharges of Stormwater from Small Municipal Separate Storm Sewer Systems. The Stormwater Management Program is designed to reduce discharge of pollutants to the maximum extent practical and to protect water quality. The Stormwater Maintenance Program includes inspection and cleaning of streets, storm drains, public areas such as alley ways, parks and other City facilities, and structural retrofits of the storm drain inlets and basins as needed.

The City's stormwater system serves the entire City limits. The City assesses and prioritizes maintenance of the storm drain system, including the following: catch basins, pipelines, five San Lorenzo River pump stations, the Neary Lagoon pump station, two CDS (hydrodynamic pollution separator) units, and above-ground conveyances. See Figures 3-10, 3-11, 3-12, 3-13, and 3-14 for stormwater infrastructure adjacent to the San Lorenzo River.

The City has determined that the lower Ocean Street, Beach Flat and Downtown areas are the highest priorities for storm drain system maintenance based upon the following factors:

1. High or intensive use,
2. High density, and
3. Direct impact or proximity to receiving waters such as the San Lorenzo River, San Lorenzo River pump stations, and Monterey Bay/Pacific Ocean.

In addition to the catch basins in the high priority areas above in the high/intensive use or high density areas, which tend to have accumulation of sediment, trash and debris, catch basin meeting any of the following criteria will also be considered high priority:

1. Catch basins known to accumulate a significant amount of sediment, trash, and/or debris;
2. Catch basins collecting large volumes of runoff;
3. Catch basin collecting runoff from area that do not receive regular sweet sweeping;
4. Catch basins collecting runoff from drainage areas with exposed or disturbed soil; or
5. Catch basins that receive citizen complaints/reports.

Staff also reviews the storm system areas that needed attention during the previous year and adds these areas to the priority list as necessary.

Inspection and Cleaning

Inspection and cleaning of streets and storm drains are a key component of the Stormwater Maintenance Covered Activity. The City implements an annual storm drain inspection and cleaning program, “Team Clean”, to remove pollutants transported by stormwaters to receiving waters such as streams and the San Lorenzo River. The City is currently developing a Geographic Information System (GIS) for storm drains to further refine cleaning frequency for catch basins and inlets. A maintenance tracking software system is also under development and will help with scheduling and tracking inspections, cleanings, upgrades, and tracking flooding of stormwater facilities. The City also conducts TV camera inspections of at least 5,000 feet of storm drain line each year. These inspections are very helpful in evaluating the conditions of storm drain lines and identifying repair needs. Cleaning is completed both through the use of a Vactor truck and through hand cleaning. Storm drain lines are plugged at both ends and the Vactor truck, using reclaimed water, “jets” the line and then vacuums the line to remove sediment and material. The resulting sediment and material are disposed of in the sanitary sewer or landfill after dewatering at the Wastewater Treatment Plant. In general, the City operates according to the following schedule for inspecting and cleaning all inlets, catch basins, pipelines, pump stations, and other portions of the storm drain system.

- Problem basins (known basins that collect sediment and trash): Inspect and clean at least monthly or more frequently during wet season.
- Intensive use basins (located in high use areas of the City): Inspect and clean semi-annually. Clean monthly during September and October.
- Commercial basins (located in commercial areas): Inspect and clean annually.
- Residential basins (located in residential areas): Inspect on an eight-year cycle and clean, as necessary.
- Pump stations along San Lorenzo River: inspect weekly and cleaned at least annually.
- Large diameter stormwater pipelines (including inlets, culverts, and vaults): Inspected annually and cleaned at least on a five-year cycle.
- Small diameter stormwater pipelines (including inlets, culverts, and vaults): Inspected on a two-year cycle, cleaned as needed or on a fifteen-year cycle.

The street sweeping program is conducted daily and covers approximately 35 miles of streets daily. Manual hand sweeping is conducted “on call” in order to clean up after a particular event or accident. Cleaning of City-owned areas (such as alleys) is conducted with a garden hose, without the use of soap. Prior to hosing, spills and large debris are cleaned or picked up. Also, aluminum grates with small mesh size are inserted into nearby storm drains inlets to prevent small debris from entering the storm drain system. Catch basins in public parking lots are cleaned with a Vactor truck annually. Wastewater from the cleaning is collected and disposed into a sanitary sewer line. City staff oversees these cleaning events to ensure proper disposal of the wastewater.

The City also maintains numerous public areas and facilities, including medians, parks and other landscape areas with hand crews and standard landscaping equipment (lawn mowers, trowels, shovels, string trimmers, etc.). The primary pollutants of concern from these properties are sediment from erosion, nutrients from fertilizer use and organic matter, and heavy metals and toxic organics from pesticides/herbicide use. The City has an active Integrated Pest Management (IPM) program and pesticide/herbicide use is very limited, conducted according to label instructions when they are used and generally avoided adjacent to waterways. Medians and embankments are planted with vegetation and maintained for both aesthetics and erosion control or hard-scaped in situations where maintenance and safety concerns warrant it.

Structural Retrofits of Storm Drain Inlets and Basins

The City selects structural retrofit projects of storm drain inlets and basins in the interest of improving performance of said infrastructure and reducing transport of stormwater pollutants to adjacent waterbodies. The City focuses on two types of structural controls to improve water quality associated with the storm drain system. The first are dry-weather diversion systems to divert flow to the sanitary sewer for treatment at the Wastewater Treatment Facility. The second are in-line treatment systems such as sediment basins and oil/water separators. Additional projects such as sealing slide/flap tide gates along the San Lorenzo River to prevent spills from entering the river have been identified as a priority for implementation in the future. This work typically occurs within street rights of way and standard best practices are employed during construction to prevent runoff and degradation of water quality in adjacent waterways. Any streamside work is also isolated from the water with coffer dams. See Section 4.4.3 for detail on best practices for water quality protection during stream work.

Leachate Management

The goal of the operation of the Leachate Collection and Removal System (LCRS) is to prevent leachate from entering into Lombardi Creek from the City's sanitary landfill and prevent the public from coming into contact with leachate. The LCRS consists of four major components: a groundwater interceptor trench-barrier wall at the toe of the RRF, two Class II surface ponds; a leachate transport pumping station and electric control building; and a transport pipeline.

There are two leachate collection ponds located at the south toe of the RRF, up gradient of the groundwater interceptor trench-barrier wall. These ponds do not support steelhead or coho but do provide habitat for California red-legged frog. These ponds serve to collect leachate resulting from rainfall and underground springs and prevent the leachate from entering into Lombardi Creek. The ponds are operated in a sedimentation and overflow scheme. The ponds are approximately 11 feet deep including 2 feet of freeboard. The primary and overflow ponds have nominal capacities of 100,000 and 175,000 gallons, respectively. The leachate sediments settle in the primary collection pond and the leachate overflows to the transfer pump station manhole. At the base of this pond is a 4-inch clean-out where operations vacuum out the sediments on an as needed basis.

The leachate transport pumping station was built between the two ponds, and houses three submersible 200 gallons per minute (gpm) wastewater pumps. Leachate flows by gravity to the pumping station or into the overflow pond when storage is required. Pumping to the Wastewater Treatment Plant is frequent enough so that the overflow pond is empty most of the time. The pump station was designed so that one pump could meet the peak month flow requirements; the third pump was provided as a backup. Most of the solids in the leachate settle out in the sedimentation pond, minimizing cleaning of the overflow pond and leachate transport line.

In the case that the leachate line would require repair due to a natural disaster (e.g., earthquake), the City would undertake repairs as expeditiously as possible, normally within 24-48 hours depending on damage. The process by which the line repair would be undertaken would include assessment by City engineers for fixing the break, assessment of equipment and operation needs, obtaining necessary permits and building the repair. Conveyance of leachate is discussed under the Conveyance Pipeline System Inspections and Repairs Covered Activity description. Work on the leachate system employs standard best practices for protection of water quality and aquatic habitat. See Section 4.4.3 for detail on best practices for water quality and aquatic habitat protection.

3.5.3 Emergency Operations and Response

Emergency operations are developed in response to specific emergency incidents of a scale that are smaller than those that trigger “Changed Circumstances”. Anticipated types of incidents that may occur in the Plan Area include localized storms, floods, fire, earthquakes, and hazardous spills that are of a short (days – weeks) time period. These incidents may result in log jams, flooding, damage to pipelines, bridges and levees, mudslides, structures damaged by high surf, and spills into waterways.

The incidence of these types of events is highly variable and unpredictable. They are likely to occur less frequently than annually and involve special-status species or designated critical habitat on an even less frequent basis. In the case emergency response is required, operations may include the use of heavy equipment near waterways and removal of debris and structures in waterways, drainage improvements, pipeline repairs, erosion control and revegetation. Operations are completed according to the City's Emergency Management Plan. The overall Project Manager during emergency situations is the City Manager with support from Fire and Public Works departments and may involve activation of the City's Emergency Operations Center. Field work is guided by authorized environmental monitors and in consultation with NMFS and CDFW as needed. Standard best practices for the protection of water quality and aquatic habitat will be employed for this activity as well. See Section 4.4.3 for detail on best practices for water quality and aquatic habitat protection.

3.5.4 General Vegetation Management Within Riparian Corridors

Vegetation management is generally conducted at City properties and facilities, pipeline rights-of-way, water diversions, tanks, pump stations, and open space and watershed lands. Vegetation management is conducted to provide access to City facilities, provide protection from fire, prevent proliferation of non-natives and illicit activity, and to improve habitat and water quality at some facilities. Vegetation removal is generally done through cutting, flaming, pulling, mowing or targeted herbicide application consistent with the City's IPM Program. Removal areas are targeted based on facility maintenance needs, safety, non-native plant invasion potential, available resources and funds, and other natural resource management priorities. Planting may also occur for landscaping or restoration purposes and is typically focused on native or drought tolerant species. Generally speaking, vegetation removal is limited to the dry months, while planting is limited to the early winter period when rooting potential is maximized. However, these activities may not occur on a regular or seasonal schedule, nor occur at a specific time of day or rate of frequency, and may occur at any time as needed.

Vegetation management for pipeline ROW access is done primarily through hand trimming and mowing on an annual basis. An eight-foot right of way along the pipeline right of way is maintained the length of pipelines and involves up to five stream crossings annually. Pruning in riparian corridors along pipeline ROWs and adjacent to other utility infrastructure is typically limited <5,000 square feet on annual basis and mostly occurs along non-anadromous stream reaches. Trimming in riparian areas is done by hand and maintains canopy, downed trees and snags to the extent possible. Mature trees are typically retained unless they are failing and threaten infrastructure. All mature trees are inspected by a certified arborist or registered professional forester before being felled and downed wood is left and not lopped as possible. All tree work is done outside of the nesting season if possible, and trees are inspected for nests prior to felling if felled within the nesting season.

3.6 Land Management

Land management activities include recreation, facility maintenance and management, and sensitive habitat management. These activities occur on City Water Department watershed lands, including the LLRA in Newell Creek watershed, and the Zayante and Laguna watershed properties in the Plan Area. The HCP includes coverage for operation, rehabilitation, replacement, repair and maintenance of existing infrastructure and related facilities. Activities associated with facility maintenance and management include facility repair, trail maintenance and management, trail construction, and road maintenance and decommissioning. These activities occur on all the watershed lands and open space properties owned by the City Water Department, particularly in the Newell Creek and Zayante Creek watersheds.

3.6.1 Management of Loch Lomond Recreation Area and Watershed Lands

The City operates the LLRA Area in the Newell Creek watershed as a condition of approval for construction of the Newell Creek Dam. Loch Lomond Recreation area is approximately 180 acres. The Water Department operates this facility with a staff of planners, rangers, and maintenance personnel. The area is operated to provide appropriate recreational opportunities for the public, to preserve and maintain habitat areas and to provide drinking water source (i.e. watershed) protection at Loch Lomond Reservoir and surrounding Newell Creek watershed lands. The City also manages approximately 3,880 acres of watershed lands in the Newell, Zayante and Laguna watersheds solely for the purpose of drinking water source protection. These lands are not open to the public and the Laguna property has no road or trail network but does include an offsite mitigation area in upslope areas for the conservation of Mount Hermon June Beetle. See Figure 1-3, Figure 1-5, and Figure 1-6 for location of Loch Lomond Recreation Area and watershed lands and associated roads.

Trail Maintenance and Repair

This activity includes repair to 7.5 miles of trails during or after natural events such as winter storms, earthquakes, or landslides. The City does not undertake this activity on a regular basis, only on an as needed basis. It typically involves less than 50 yards of trail in any given year. In cases where a project has been identified as needed to ensure public safety and prevent degradation to sensitive resources, the City prepares a project description, obtains repair specifications, obtains project specific approvals from NMFS, CDFW if riparian corridor or stream work is involved and constructs the project. Trail maintenance and management occurs year-round on open space properties and watershed lands. Trail maintenance and management is a preventative activity to keep trails in good physical conditions to avoid blow-outs due to natural events. Trail maintenance can include installing drainage improvements such as culverts, dips and bars and realigning trail segments outside of stream channels and geologically unstable areas and steep slopes and otherwise avoid other sensitive habitats. Culverts are not installed on salmonid streams. Remediation of existing erosion areas is implemented annually as needed. Informal and unauthorized trails are discouraged or removed as resources permit. Ranger patrols are provided to ensure appropriate use of trails and adherence to closures or restrictions. Areas that have sensitive resources (such as riparian areas) are also closed to public use to prevent disturbance to those resources. Standard BMPs are required for facility repair work near riparian corridors and streams. More detail on such measures can be found in Section 4.4.

Road Maintenance and Decommissioning

Road maintenance and decommissioning occurs on the Newell Creek and Zayante Watershed properties owned and operated by the Water Department. Road maintenance and decommissioning is conducted on the watershed lands to maintain access on vital roads. Road maintenance occurs annually on the property, from May-September and can take a few days to several weeks to complete. Road decommissioning is a new activity for the Department and is in its initial stages of planning and implementation but is expected to continue over the next 20 years. All road work is conducted with the support of a Registered Professional Forester and Certified Erosion Control Specialist, with engineers also being involved on more difficult road projects.

Roads are maintained to provide access for patrolling the properties for security and trespass concerns (off road vehicles, poaching, camping, etc.), for fire access, resource management and restoration, and for maintenance of drainage infrastructure. Roads not necessary for these purposes, or which are significant sediment sources which cannot be treated by maintenance activities, will be decommissioned.

Road maintenance takes place on “restricted use” or seasonal roads within the Newell Creek and Zayante watershed lands and on City park properties. Maintenance is done on the paved maintenance road to the LLRA and unpaved roads in the watershed lands. Maintenance activities focus on maintaining 117 culverts and associated trash racks, maintaining proper energy dissipation at outlets, clearing bank slough, and conducting bank stabilization, and hand digging rolling dips and/or water bars as necessary to maintain appropriate drainage. This work does not occur in salmonid streams but may occur in ephemeral or perennial tributaries to salmonid streams. Drainage maintenance is usually done with hand tools and bank slough is accomplished with hand tools or a small tractor or loader. Large fill failures or crossing failures are emergency repairs and are not considered standard maintenance.

Unpaved roads are managed as “restricted use” roads. The restricted use refers to roads that are not appropriate for driving in the winter under saturated conditions. These roads are generally maintained as out-sloped dirt roads, with rolling dips and/or water bars to manage drainage. Culverts are utilized to route drainages that the road would otherwise intercept, through the road prism, or in a few areas where in-sloping had to be maintained to pick up bank seepage, or control drainage away from a landslide or road fill failure. These roads have been historically maintained as dirt surface roads, with no wet season use. In an attempt to reduce road surface sediment production, to improve access for patrols or emergencies, and to extend the season that the roads can be traveled, these roads can be rocked. At this time, the main road on the Newell Creek watershed lands, from the dam to the Bear Creek access is envisioned for rocking. The east side road in the recreation area may be treated with drain rock at stream crossings, or at road segments which could introduce sediment into water courses, but is not as vital to upgrade for patrol.

Additional maintenance activities for roads would include culvert replacement and road reshaping. These activities would not occur annually as the prescriptions described above, but would rather be done according to management priorities. Culvert replacement or upgrades would occur in July – September with hand tools and heavy equipment. Projects could take several days to several weeks to complete. The Water Department is planning for a 30-year rotational schedule for culvert replacement and upgrades. Road maintenance on the 34 miles of watershed lands forest roads would occur approximately every five years and would include reshaping roads to maintain outslope drainage as appropriate for the road and topography. Effectively, this means that approximately 136-170 miles of forest roads are reshaped every 20 years and an average of 6.9 miles of road will be maintained annually. Reshaping work is done within the existing road width and cut fill area for most roads and no additional disturbance is done to adjacent areas. After reshaping, the roadbed is rocked and straw and seed are applied to bare soil areas as necessary. Once reshaping has been accomplished for identified roads, the frequency of repeat treatment would be approximately every 8-10 years.

Road decommissioning may occur for up to 5 miles of roads in the Newell Creek and Zayante Creek watershed lands in the future. Road decommissioning varies according to topography, road placement and construction technique when the road was built. Many segments of the roads proposed for decommissioning traverse relatively mild slopes and have few drainage structures (culverts). These road segments would be more severely out-sloped than a drivable road, or sloped as close to natural grade as possible without generating excessive levels of disturbance. Where water may still concentrate on the road, frequent, large water bars will also be constructed. A small bulldozer (D-6) could adequately decommission these roads, possibly with the assistance of an excavator or backhoe.

These road segments would require all fill to be removed from the down slope portion of the road. This material would then be placed on top of the roadbed cut surface (keyway) and compacted against the existing cut bank. Compaction could be track walking or tamping with excavator in more benign areas. In the more difficult, steep areas, the fill would be engineered (with compactor, sheepsfoot, etc.) and watered per geotechnical recommendations. A severe out-slope would be constructed to bring the contour to as close as natural grade as possible. The area of disturbance associated with road decommissioning is the 14-16 foot width of the roadbed plus an additional 15-20 feet for the recontouring of the more benign roads, and 20-30 feet for the more difficult ones. The number of culverts involved in any given road segment could range from 15-20 culverts (average of 3.4 culverts/mile of road) on either perennial or ephemeral drainages. These drainages do not support the presence of steelhead or coho but may support resident trout.

Culvert removal will consist of excavating the culvert fill with an excavator or backhoe, down to native grade, and removal of the culvert. The area of disturbance associated with culvert removal would typically consist of the 14-16 foot wide roadbed, plus the area to the outer edge of the fill (10-20 feet). The road length at a particular crossing would typically vary from 20-50 feet. Depending on the grade of the channel to be reestablished, and other channel conditions, additional work may be necessary for grade control and energy dissipation above and below the culvert removal site. It is anticipated that most channel adjustments from culvert removal would occur within 30-50 feet of the existing crossing. Gabion sized rock to small rip-rap, or placement of large wood in the channel, may be necessary for channel stabilization upstream and/or downstream of the removed crossing. Erosion control measures for surface stabilization following removal would be required (straw, seed, straw rolls, blankets etc.), and the area replanted with native species, particularly conifer and riparian species.

Road decommissioning would take place during June – September. Road segments would be chosen so that they could be decommissioned, stabilized for erosion, and replanted within one season. Once decommissioned, maintenance would be reduced to any follow-up erosion control and further planting/care necessary for an additional period of one to two years until the area is stabilized and growing.

3.6.2 Habitat Management and Restoration

Habitat management includes resource management activities to improve, preserve and maintain existing sensitive habitats and species. Activities include habitat management and restoration, and public education.

Aquatic Habitat Management and Restoration

Aquatic habitat management is conducted to protect and enhance aquatic habitat for fish, amphibians, and reptiles and will be a fundamental component of the non-flow components of the conservation strategy. Fisheries restoration projects focus on adding or protecting fisheries habitat, stabilizing streambank erosion problems when it benefits salmonid habitat, protecting riparian corridors, removing fish passage barriers and related actions within the Santa Cruz Mountains coho diversity stratum. Projects are completed in accordance with the methods detailed in the California Salmonid Stream Habitat Restoration Manual (Flossi et al. 1998) and appropriate state and federal authorizations will be obtained prior to doing the work. Project priorities will be made with the assistance of a Technical Advisory Committee (TAC) as described in the Non-flow Conservation Fund (NFCF)(Appendix 1: *Summary of Approach to Non-Flow Mitigation of Biological Effects of the City Diversions*). Project types and respective equipment details are variable. For example, equipment used may range from chainsaws (for dropping trees into the streams), to excavators and log skidders for placement of large wood/boulders/gravel and related materials which must be brought into an area where there is existing access from roads. Hand crews are also typically involved in instream projects.

These activities take place during the summer/ fall period, when work conditions are dry, and the critical spawning and smolting periods are over. These projects could occur annually for smaller focused projects to every few years for larger projects (longer stream reaches, more complex construction). Typically, streams are dewatered for this work though they may not be for more simple projects where dewatering would be more impactful than working within the wetted channel. It is estimated that these types of projects would involve dewatering and fish removal in < 100 yards of stream per year. It is estimated that the time length of the projects will vary from 2 to 6 weeks. Standard BMPs are required for work near riparian corridors and streams. More detail on such measures can be found in Section 4.4.

Monitoring

The HCP monitoring program will provide the information necessary to assess compliance with the terms of the HCP, verify progress toward the biological goals and objectives, validate effectiveness of habitat management and restoration actions and implement a feedback loop to ensure that management/mitigation measures of the HCP can be changed as needed in response to changing conditions and new knowledge. The monitoring program is summarized here and more fully described in Section 6.4. The monitoring program will be overseen by the HCP Administrator and methods and results will be reported in an annual monitoring Covered Species report.

The monitoring program outlined below will provide data on the distribution and abundance of their habitats, and potential threats. Using these data, the City will be able to assess changes in the quality and quantity of the specific habitat of the Covered Species, identify significant changes in the populations of the Covered Species, measure progress towards meeting the HCP's Biological Goals and Objectives, and decide if changes in management or monitoring are warranted. The results of the annual monitoring activities will also inform management decisions, including selection of projects to be funded from the mitigation fund.

All monitoring activities will be performed under the HCP Administrator's guidance and supervision, or under the guidance and supervision of a designated Conservation Program Manager. Prior to the implementation of the HCP, the Conservation Program Manager will prepare a monitoring manual that specifies the methods and protocols to be used in the Monitoring Program. Monitoring objectives, methods, and specific protocols will be developed in close coordination with NMFS and CDFW through a TAC to reflect the state of the art in regional salmonid assessment and to ensure consistency with regional efforts as they develop. Training will be provided for all individuals performing monitoring activities and these individuals will have qualifications, knowledge, and experience relevant to the type of research and monitoring activities that are being performed. The HCP Administrator may engage third parties (such as biological consultants with specific technical expertise regarding a Covered Species) who are qualified and authorized by NMFS to conduct, or to directly supervise, activities conducted under the HCP's monitoring program.

Monitoring program coordination with NMFS and CDFW will be achieved through regular meetings (at least one to two per year) of the HCP TAC. Meetings will include a review of results of the past seasons monitoring and finalization of plans for the upcoming monitoring season. The value of existing studies will be appraised, and monitoring elements may be revised accordingly. An annual report will be prepared to document all monitoring activities and results. The three elements of the monitoring program (Compliance Monitoring, Population and Habitat Monitoring, Mitigation Effectiveness Monitoring) are summarized below. A full description of the monitoring plan is provided in Chapter 6.

Compliance monitoring will include the following:

- Incidental take tracking
- Instream flow targets
- Felton Diversion operations
- Copper monitoring at Loch Lomond Reservoir
- Testing deluge and gate valves

- Relocation of LWD downstream of Loch Lomond Reservoir
- Installation of Sediment Management upgrades at Laguna, Reggiardo, and Majors Diversions
- Installation of Felton Diversion and Tait Street Diversion Fish Screen Upgrades and juvenile bypass improvements
- Water System Operations and Maintenance avoidance and minimization measures
- Municipal Facilities Operations and Maintenance effects on listed species and habitat (debris/obstruction removal, sediment removal, and vegetation removal)

Covered species population and habitat monitoring will include:

- Juvenile population abundance in HCP stream reaches
- Juvenile population abundance in San Lorenzo and Laguna Creek lagoons
- Adult population abundance at the Felton Diversion Dam
- PIT tag antenna array in the San Lorenzo River
- Stream habitat quality
- Instream temperature
- Passage obstacles
- Lagoon habitat quality

Monitoring activity specifically requiring take authorization includes habitat typing of up to 20 miles of streams and tagging/handling of <10,000 fish annually, visual census of up to 5,000 feet of stream annually and maintenance of up to 10 stream gages, 2 pit tag readers, 10 temperature loggers, 1 fish trap and 2 water quality data sondes annually. Monitoring will utilize typical best practices for working in streams as described in Section 4.4.3 and be covered under the 10(a)(1)(B) and related Scientific Collector's permit.

Mitigation effectiveness monitoring will be completed for each mitigation project after 1, 3, 5, and 10 years. Monitoring objectives and methods, and specific protocols will be specified for each mitigation project by the TAC as part of the mitigation planning process. The mitigation strategy is based on a stepwise process of habitat enhancement that will occur over the life of the HCP. The City will provide annual funding for projects, and the TAC will decide on projects and allocate funds (see Chapter 4 for a description of the mitigation program).

Reporting for each mitigation project will be provided in the annual and five-year mitigation summary reports and will include information on attainment of project-specific success criteria (via review of assessment variables to be prescribed for each project by the TAC), responsible party, specific monitoring methods, a schedule of monitoring activities, analytical methods, and reporting requirements.

Table 3-3: Covered Activities Summary

General Activity	Sub-Activity	Notes
Rehabilitation of Diversion Structures and Pipeline Reaches	1. Laguna Diversion 2. Majors Diversion 3. Felton Diversion 4. Tait Street Diversion	1. Sediment transport improvements 2. Fish screening improvements 3. Fish passage improvements at the Tait Street and Felton diversions 4. Diversion capacity increase at the Tait Street Diversion.
Water Diversion	1. Liddell Diversion 2. Reggiardo Diversion 3. Laguna Diversion 4. Majors Diversion 5. Newell Creek Dam 6. Felton Diversion 7. Tait Street Diversion and Wells	Provision of drinking water utilizing existing water rights (as described in the proposed Santa Cruz Water Rights Project) with addition of “Conservation Flows”
Reservoir Operations	1. Chemical Algaecide Treatment of Reservoir 2. Testing Deluge and Gate Valves 3. Woody Debris Removal on Reservoir Face	1. 1-5 algaecide treatments annually 2. 1 test annually of 5-10 cfs for several hours. Bigger tests during winter/high flows as possible. 3. 10 cubic yards of < 10” diameter/8’ long wood removed annually
Water Diversion Sediment Management	1. Liddell Spring 2. Laguna Diversion 3. Majors Diversion	1. Excavation of up to 3 yards per event up to 1-3x/year. Valve operations. 2. Excavation of 5-10 cubic yards per event up to 1-3x/year. Valve operations. 3. Excavation of 5-10 cubic yards per event up to 1-3x/year. Valve operations.
Fish Ladder and Screen Maintenance	1. Felton Diversion 2. Tait Street Diversion	1. 1-3 x/year up to a yard of sediment and woody material needs to be removed from the ladder.

		2. 1-3x/year up to a yard of sediment and woody material needs to be removed from intake.
Pipeline Operations	1. Conveyance Pipeline System Inspections and Repairs 2. Finished Water Pipeline System Flushing and Repairs 3. Pumping Well Return to the San Lorenzo River 4. North Coast Valve Blow Off to the San Lorenzo River	1. Inspection and leak response on 19.23 miles of water line and 5.5 miles of leachate line. 2. Flushing and leak response on 270 miles of water line. 3. Ongoing pumping from clear well to remove sediment during high and moderate flows in winter and spring. 4. 5-10 cfs blow off to riverbank occurring < 1x time/year during any part of the year for 1-4 hours.
Dewatering of Creeks for Maintenance and Repairs	1. NA	1. Dewatered stream reaches can range from approximately 20-200 feet at 1-10 sites for 1-4 weeks in any given year.
Flood Control Maintenance	1. Debris/Obstruction Removal 2. Flood Control Sediment Management/Removal 3. Vegetation Management	1. 1-3x/year in wet water years up to 100 cubic yards of material. 2. Removal of approximately 2 cubic yards of sediment per drainage structure/annually or biannually for up to 30 drainage structures. 3. Thin riparian groves and remove willows >3” dbh and alders >6” dbh. Retain 5-10 foot wide riparian buffer adjacent to low flow channel, but remove vegetation >6” dbh annually.
Stormwater Maintenance	1. Inspection and Cleaning 2. Structural Retrofits of Storm Drain Inlets and Basins 3. Sanitary Landfill Leachate Management	1. Inspect and clean as needed but as frequently as weekly. Sweep 35 miles of streets daily. 2. As needed improvements of storm drain infrastructure.

		3. Ongoing maintenance of two leachate ponds, transmission of leachate to wastewater plant and repair of leachate line.
Emergency Operations and Response	1. NA	1. Response to flood, fire, spill, or other related incident on a <1 time/year basis and lasting from a few days to several weeks.
General Vegetation Management Within Riparian Corridors	1. NA	1. Pruning and limited removal of riparian trees <5,000 square feet on an annual basis during the summer/fall months as needed adjacent to pipeline ROWs, water diversions and other utility infrastructure.
Land Management	1. Management of Loch Lomond Recreation Area and Watershed Lands 2. Trail Maintenance and Repair 3. Road Maintenance and Decommissioning	1. Operation and management of 180-acre recreation area and 3,880 acres of open space. 2. <50 yards of trail in non-anadromous watersheds annually. 3. Maintenance: Approximately 6.9 miles of road maintained annually. Decommissioning: 0-1 miles of road including up to 3.4 culverts on non-anadromous drainages annually
Habitat Management and Restoration	1. Aquatic Habitat Management and Restoration 2. Monitoring	1. Dewatering and fish removal in <100 yard stream reach annually 2. Habitat typing up to 20 miles of stream and tagging/handling of <10,000 fish annually. Visual census of up to 5,000 feet of stream annually. Maintenance of up to 10 stream gages, 2 pit tag antennas, 10 temperature loggers, 1 fish trap and 2 water quality data sondes annually

4.0 CONSERVATION STRATEGY

The conservation strategy is designed to avoid, minimize, and fully mitigate the effects of City covered activities on Covered Species and their habitat in support of the long-term viability of these populations within streams affected by the Covered Activities. The ultimate fate of these populations depends on the actions of many other entities and natural processes both within and beyond areas under the City's control. The conservation strategy recognizes that the City's efforts will support and coordinate with overarching efforts to preserve these species within Santa Cruz County and the larger DPS and ESU boundaries. The biological goals and objectives address key limiting conditions in the Santa Cruz Mountain diversity stratum, particularly effects of diversions, as identified in the recovery plans for steelhead and coho (NMFS 2016, NMFS 2012). The Conservation Strategy assumes, and is dependent upon, approval of the pending Santa Cruz Water Rights Project with the State Water Resources Control Board (as described in Section 6.2.1).

4.1 Introduction

The City's process in developing the conservation strategy included a thorough review of available data and literature on the species and extensive field data collection, including the status and features of populations and habitat conditions within each stream. This analysis resulted in the identification of limiting factors (Chapter 2) and an understanding of the potential effects of Covered Activities on these species and their habitats. As described in Chapter 1, the City coordinated closely with NMFS and CDFW to address research methodologies and results, and to develop the conservation strategy. The following sections describe the City's approach to the conservation strategy, the overall biological goals and objectives, and specific measures to achieve those goals and objectives.

4.2 Approach to the Conservation Strategy

The primary focus of the City's conservation strategy is to avoid or minimize existing and potential effects of Covered Activities to the maximum extent practicable. To achieve this, the Conservation Strategy has been structured around Biological Goals and Objectives (Section 4.3), avoidance and minimization measures (Section 4.4), and a non-flow conservation program (Section 4.5). The biological goals and objectives provide a statement of desired future conditions and provide the basis for determining strategies, monitoring effectiveness, and evaluating the success of actions. The avoidance and minimization measures define specific tools and techniques and measurable steps to meet HCP objectives and achieve desired future conditions. The avoidance and minimization measures may involve the removal of an activity from a particular location or the scheduling of an activity to occur during a period in which the species is unlikely to be affected. Avoidance and minimization measures may also apply constraints or limitations on an activity that allow it to proceed while avoiding or minimizing effects to species. In cases where avoidance and minimization measures are insufficient to entirely avoid potential effects, the City will implement a mitigation program that will fund habitat enhancement and restoration through the NFCF to fully offset those remaining effects (Section 4.5).

Steelhead populations in the North Coast streams are relatively small due to the short lengths of anadromous habitat. Analysis of monitoring data suggests adult populations on the order of less than half a dozen for Liddell and Majors Creeks and about 60 for Laguna Creek, of which over 90% would be from the lagoon (Section 2.5). Even if stream densities were 3 to 4 times higher, these would still be very small populations. A similar analysis of data from Newell Creek suggests potential spawning populations of about 17 adult steelhead on average (Section 2.5). The San Lorenzo River Lagoon has the potential to produce a relatively large number of steelhead smolts. Analysis based on juveniles rearing in the lagoon suggests a potential adult return of up to approximately 400 adult steelhead from these juveniles in addition to those from production in the mainstem and tributaries (Section 2.5).

This analysis, while somewhat hypothetical, indicates the relative importance of the San Lorenzo River Lagoon and Laguna Creek Lagoon in supporting steelhead populations in the Plan Area and the relatively small contribution of Newell Creek and the other North Coast streams. The San Lorenzo River is a high priority for restoration. It is a large watershed with extensive anadromous habitat with approximately 26 miles of anadromous habitat in the mainstem and 57 miles in the tributaries (ENTRIX, Inc. 2004b). The San Lorenzo River supports steelhead and potentially supports coho. Although the lagoon is highly altered from pre-development conditions and the habitat is significantly degraded, it is still important for rearing juvenile steelhead (Chapter 2). While coho are functionally extirpated from the San Lorenzo River and North Coast streams, the river is a focus of recovery efforts by NMFS and together with some of its tributaries, may play an important roles in the recovery strategy for Central California Coast coho (NMFS 2010).

The City's objective is to use available water supplies to restore natural flow regimes at times and locations where it will have the most beneficial effects on steelhead and coho production. In order to meet this objective, priorities were established for the different streams and life-stages influenced by City diversions. The San Lorenzo River is important because of the large amount of potential habitat compared with other Plan Area streams, the potential to support both steelhead and coho, and the relative magnitude of potential effects of City activities on anadromous species. The San Lorenzo River Lagoon is important for its potentially large contribution to the steelhead population from juveniles reared there. Of the North Coast streams, Laguna Creek was given highest priority since it has the greatest length of anadromous habitat influenced by City diversion; it is the only one with a functional lagoon system; it has experienced the largest proportional flow diversion; and it has more frequent observations of coho reproduction in recent years (2005, 2015, 2016, 2020). Liddell Creek was given the lowest priority since the City diversion influences only a portion of the potential anadromous habitat; base flows are generally higher in the anadromous reach due to augmentation from the West Branch, the Middle Branch, and basin hydrology; there is no lagoon; and there is a high level of fine particles in the substrate that diminish habitat quality and potentially limit the benefits of any flow augmentation.

4.3 Biological Goals and Objectives

This section describes the Biological Goals and Objectives. Biological Goals are broad, guiding principles based on the conservation needs of the resources. Biological Objectives are expressed as conservation targets or desired conditions for each Biological Goal. As described below, Biological Goals involve provision of bypass flows at each diversion source to improve habitat conditions; creation, restoration, and enhancement of physical habitat to mitigate any residual effects of the diversions; and avoiding, minimizing, and fully mitigating effects to Covered Species resulting from City operations and maintenance activities.

Biological Goal # 1 Contribute to the conservation of Covered Species by providing flows sufficient to improve habitat conditions and increase the likelihood of persistence of populations within the Plan Area.

Objective 1.1 Within two (2) years of permit issuance, and for the duration of HCP implementation, increase the quantity and quality of habitat supporting adult migration in terms of average number of days with flow meeting minimum migration criteria during the adult migration period (December through April for steelhead, December and January for coho).

<u>North Coast Streams</u>

Objective 1.1.1 Steelhead

Provide at least 95% of no-diversion levels in Laguna Creek in all year types and at least 90% of no-diversion levels in Majors and Liddell Creeks in normal and wet year types.

Objective 1.1.2 Coho

Provide at least 90% of no-diversion migration levels in Laguna Creek.

San Lorenzo River

Objective 1.1.3 Steelhead

Provide a minimum of 92% of no-diversion migration levels below Tait Street in dry, normal, and wet years; 75% in critical dry years. Provide 100% of no-diversion migration levels downstream of the Felton Diversion.

Objective 1.1.4 Coho

Provide a minimum of 84% of no-diversion levels for average migration days below Tait Street in dry, normal, and wet years; Provide 70% of no-diversion levels in critical dry years. Provide 100% of no-diversion levels downstream of the Felton Diversion.

Objective 1.2 Within two (2) years of permit issuance, and for the duration of Plan implementation, increase the quantity and quality of habitat supporting spawning as measured by average annual WUA during potential spawning periods (after migration event in December-May for steelhead, December-March for coho).

North Coast Streams

Objective 1.2.1 Steelhead

Provide a minimum of 94% of no-diversion spawning habitat index levels in Laguna Creek in all year types. Provide a minimum of 90% of no-diversion habitat index levels in Majors and Liddell Creeks in normal and wet year types.

Objective 1.2.2 Coho

Provide at least 95% of no-diversion spawning habitat index levels in Laguna Creek in all year types.

San Lorenzo River

Objective 1.2.3 Steelhead

Provide at least 90% of no-diversion spawning habitat index levels downstream of the Felton Diversion.

Objective 1.3 Within two (2) years, and for the duration of Plan implementation, increase the quantity and quality of habitat supporting juvenile rearing as measured by seasonal average (winter, spring, summer) rearing WUA.

North Coast Streams

Objective 1.3.1 Steelhead

Provide at least 83% of no-diversion rearing habitat index levels in Laguna Creek in all year types during the spring (April through June) and summer (July through September) periods. Provide at least 70% of no-diversion habitat index levels in Majors and Liddell Creeks during spring and summer in normal and wet year types.

Objective 1.3.2 Coho

Provide 100% of no-diversion rearing habitat index levels in Laguna Creek during spring and summer in all year types.

San Lorenzo River

Objective 1.3.3 Steelhead

Provide at least 85% of no-diversion rearing habitat index levels downstream of the Tait Street diversion; provide at least 98% of no-diversion habitat index levels downstream of the Felton Diversion.

Objective 1.4 Smolt Outmigration - Within two (2) years of permit issuance, and for the duration of Plan implementation, increase the quantity and quality of habitat supporting smolt outmigration as measured by annual number of days with flows meeting minimum migration criteria during the smolt migration period (January through May).

North Coast Streams

Objective 1.4.1 Steelhead and Coho

Provide an average of at least 98% of no-diversion migration levels in Laguna Creek in all year types. Provide at least 94% of no-diversion migration levels in Majors and Liddell Creeks in normal and wet year types.

San Lorenzo River

Objective 1.4.2 Steelhead and Coho

Provide at least 96% of no-diversion migration levels below the Tait Street Diversion in dry, normal, and wet year types; provide 88% of no-diversion migration levels below the Tait Street Diversion in critical dry years; provide at least 98% of no-diversion levels downstream of the Felton Diversion.

Objective 1.5 Within two (2) years of permit issuance and for the duration of Plan implementation, improve rearing habitat in the San Lorenzo River Lagoon by providing minimum inflow of 8 cfs to improve temperature and DO levels during periods when the lagoon is closed.

Biological Goal # 2 Contribute to the conservation of Covered Species by creating, restoring, or enhancing aquatic habitat in the Plan Area.

Objective 2.1 Between years 1-10, fund and oversee habitat restoration or enhancement projects worth $2.7M (2018 dollars excluding administration) and potentially including removal of passage obstacles, placement of large wood structures, riparian conservation easements, spawning gravel augmentation, riparian restoration, and sediment control projects.

Objective 2.2 Between years 11-20, fund and oversee habitat restoration or enhancement projects worth $2.7M (2018 dollars excluding administration) and potentially including removal of passage obstacles, placement of large wood structures, riparian conservation easements, spawning gravel augmentation, riparian restoration, and sediment control projects.

Objective 2.3 Between years 21-30, fund and oversee habitat restoration or enhancement projects worth $2.7M (2018 dollars excluding administration) and potentially including removal of passage obstacles, placement of large wood structures, riparian conservation easements, spawning gravel augmentation, riparian restoration, and sediment control projects.

Biological Goal # 3 Avoid, minimize, and fully mitigate effects to Covered Species resulting from City operations and maintenance activities.

Objective 3.1 During all years of Plan implementation, operate facilities to avoid stranding Covered Species by implementing a ramping rate during flow changes at the Felton Diversion Dam, Tait Street Diversion, Laguna Creek Diversion, Liddell Spring Diversion, Majors Creek Diversion, and Newell Creek Dam to limit flow reductions such that change in stage is limited.

Objective 3.1.1 Manage inflation and deflation of the Felton Diversion Dam to maintain stage increase of less than 1.68 feet per hour during deflation of the dam and stage decrease of no more than -0.55 feet per hour during inflation of the dam. This will be accomplished through manual operation of the dam bladder by a trained operator. Inflation and deflation of the dam in response to anticipated changes in the hydrograph from forecast storms will be planned in advance in consultation with staff hydrologists to minimize stage changes to the maximum extent practicable.

Objective 3.1.2 Implement a ramping rate during flow changes at Tait Street Diversion, Laguna Creek Diversion, Liddell Spring Diversion, Majors Creek Diversion, and Newell Creek Dam to limit flow reductions such that change in stage is no greater than 0.16 feet per hour when fry may be present (January 15 through May 31) and no greater than 0.3 feet per hour at other times.

Objective 3.2 During all years of Plan implementation, operate facilities to reduce introduction of sediment.

Objective 3.2.1 Deflate the Felton Diversion Dam during the first one or two rainstorms of the season to flush sediments and organic matter from the channel and at flows greater than 2,000 cfs, when the majority of sediment is being transported.

Objective 3.2.2 Within ten (10) years of permit issuance, upgrade diversion facilities on Laguna, Reggiardo, and Majors Creek to provide sediment transport during high flows so as to avoid “pulsing” of sediment to downstream habitat.

Objective 3.3 Within ten (10) years of permit issuance, enhance fish passage through the Felton Diversion Dam by upgrading facilities to meet current NMFS and CDFW criteria for fish screens and passage.

Objective 3.4 Within ten (10) years of permit issuance, enhance fish passage through the Tait Street Diversion by modifying the Tait Street Diversion to prevent entrainment and impingement and provide bypass in accordance with current criteria issued by NMFS and CDFW (NMFS 2006) and (CDFW 2000).

4.4 Avoidance and Minimization Measures for Covered Activities

The City has reviewed the Covered Activities and their possible effect on steelhead and coho life stages and has identified avoidance and minimization measures to eliminate or reduce effects to the extent practical. These avoidance and minimization measures include existing standard practices and SOPs previously put into place by the City to avoid or minimize effects on habitat and species and include approaches such as work area and work period restrictions. Avoidance and minimization measures also include City programs that provide environmental benefits through reducing pollutants and conserving water. Avoidance and minimization measures are an important part of the conservation strategy for steelhead and coho because they provide either complete protection for the species from the activity or provide for minimization of effects through implementing practices that reduce effects on life cycle stages or habitat.

This section describes measures that will be adopted under the HCP to avoid and minimize effects on steelhead and coho applicable to each City Covered Activity. City activities with the potential to affect steelhead and coho include: rehabilitation of diversion structures and pipelines, water supply operations, including diversion of streamflows and reservoir management; water system operations and maintenance including sediment management, fish ladder and fish screen maintenance, and pipeline operations and maintenance; municipal facility operations and maintenance, including maintenance of flood control facilities in the Lower San Lorenzo River and Branciforte Creek; and management of watershed lands in the Mountain Charlie/Zayante Creek and Newell Creek watersheds.

4.4.1 Rehabilitation of Diversion Structures and Pipeline Reaches

The NCS pipeline reaches extend above and below ground, through developed and undeveloped areas, and traverses along, above or beneath roadways and waterways from Bonny Doon to the west side of Santa Cruz (Section 3.2). Rehabilitation work entails replacement of portions of the supply pipelines, rehabilitation of the Majors Creek and Laguna Creek diversion structures, and rehabilitation of the Tait Street and Felton Diversions on the San Lorenzo River.

The potential for effects to steelhead and coho from pipeline rehabilitation is very low. Construction practices and measures to minimize and avoid sediment discharge to water courses, and contain sediment and spills are expected to result in negligible residual effects of this activity to steelhead or coho (Section 4.4.3, Measures WO-1 through WO-14). Work in and around stream channels will incorporate avoidance and minimization measures associated with pipeline repair (Section 4.4.3.3) and dewatering of creeks for maintenance and repairs (Section 4.4.3.4).

The Majors Creek and Laguna Creek diversion structures are located upstream of the anadromous reaches on the creeks and potential construction effects would be limited to the local non-anadromous sites. Neither rehabilitation project would affect established bypass flows for fish and both would result in more natural sediment transport in the stream channels. Rehabilitation of the Tait Street and Felton Diversions are addressed in Section 4.4.2.1.

4.4.2 Water Supply Operations

This section describes the overall approach to minimizing the effects of water diversions on the Covered Species.

4.4.2.1 Water Diversions

This section describes the potential effects of water diversions on the Covered Species and presents specific measures to avoid or minimize those effects. Flow reductions due to diversion of water at the six City diversion facilities is the Covered Activity with the greatest potential to affect steelhead and coho in the Plan Area. There are currently no instream or bypass flow requirements for the Tait Street or North Coast diversions, although diversion amounts are limited by water rights and facilities limitations. In this section, minimum instream flows are specified for each of these sources that would be maintained through flow bypasses at the City diversions. As previously mentioned, ongoing provision of minimum instream flows is contingent upon successful implementation of the proposed Santa Cruz Water Rights Project (as described in Section 6.2.1).

Early work in developing the HCP focused on understanding the relationships between flow and habitat quality downstream of each of the diversions (HES 2014b, Appendix 3: *Flow Studies*). Streamflow-habitat relationships were developed using the PHABSIM model of the Instream Flow Incremental Methodology (Bovee et al. 1998), and other analytical techniques (Thompson 1972, Powers and Orsborn 1985). This allowed quantification of habitat metrics (such as number of days with streamflow levels suitable for migration, spawning area, and rearing area) as a function of streamflows. Bypass flow scenarios were developed and evaluated using the City's operations model (Confluence), historical hydrologic data, and habitat models to optimize instream habitat conditions for covered species and City water supply needs. This process was the combined effort of a technical working group convened by the City beginning in 2005 and composed of resource agency personnel representing NMFS and CDFW, City staff, and consultants. A more detailed description of the overall approach to minimizing the effects of the City diversions and the common rationale for determining minimum instream flow targets is provided in Appendix 9: *Rationale for Determining Minimum Instream Flow Targets*. Avoidance and minimization measures, including bypass flow schedules, is provided for each of the City diversions in the following sections.

Due to the extreme range of seasonal and inter-annual flow variation occurring in HCP streams and the inability to predict flow conditions from month to month during the wet season, the bypass flows are specified on a month-by-month basis for each of five different hydrologic exceedance conditions. The hydrologic conditions (HC) are based on the record of cumulative daily average flow at the Big Trees gage on the San Lorenzo River (see Appendix 9: *Rationale for Determining Minimum Instream Flow Targets*). Cumulative water-year flow was calculated for each month in the record (water-years 1937-2015) and sorted from lowest to highest. This record was split into five equal parts representing a range of exceedance categories from 100% (flow exceeded 100% of the time) to 0% (flow never exceeded). This results in five HC classes for very dry, dry, normal, wet, and very wet conditions as HC 5, 4, 3, 2, and 1, respectively). Hydrologic condition limits by month are shown in Table 4-1. Over time, and particularly with changing climate conditions, frequency of occurrence in each Category may diverge from historical frequencies.

Operationally, the hydrologic category is determined each month based on the cumulative water year flow at Big Trees for the preceding month. This approach is not intended to replace, and is not incompatible with, the forecasting model used by the City, which is based on four year-types with a determination made in March for the current water-year. Rather, it provides an additional tool for dealing with the complexity of species habitat needs. Using the water-year type to define bypass flow requirements means that the water-year type is undefined until March and there would be no basis for provision of bypass flows during the important and dynamic winter months. Bypass flows based on the previous seasons runoff result in the potential for in-stream flows that can be too low in wetter winters following a dry year (negatively impacting habitat), or too high in dryer winters following a wetter year (negatively impacting City supply). Although bypass flows are determined based on the HC system, results are still presented by water-year type for consistency with other City programs. The hydrologic condition changes from month to month while the water year applies to a complete annual cycle. Each water year may be composed of months having a variety of hydrologic conditions. For example, a wet water year may start with a dry fall and early winter with HC-4 or HC-5 from October through January, then have a very wet February ending in HC-2 or HC-3 and a wet March ending in HC-1 or 2.

Table 4-1: Hydrologic Condition Limits for End of Month Cumulative Daily Flow (cfs) for Water Year at San Lorenzo River Big Trees Gage, Period of Record 1 October, 1936 to 30 September, 2015*

Hydrologic Condition Limits (End of Month Cumulative Daily Flow from October 1 in cfs)					
	Category 5 80-100 %	**Category 4 60-80%**	**Category 3 40-60%**	**Category 2 20-40%**	**Category 1 0-20%**
Oct	<=459	460 to 539	540 to 709	710 to 875	>875
Nov	<=1186	1187 to 1497	1498 to 1827	1828 to 2485	>2485
Dec	<=2397	2398 to 3134	3135 to 5642	5643 to 10196	>10196
Jan	<=4322	4323 to 8456	8457 to 16694	16695 to 28019	>28019
Feb	<=8442	8443 to 16368	16369 to 29140	29141 to 42995	>42995
Mar	<=13004	13005 to 22948	22949 to 35371	35372 to 57968	>57968
Apr	<=14203	14204 to 24491	24492 to 39487	39488 to 67884	>67884
May	<=15448	15449 to 25279	25280 to 41659	41660 to 71412	>71412
June	<=16005	16006 to 26116	26117 to 43123	43124 to 73420	>73420
Jul	<=16364	16365 to 26819	26820 to 44073	44074 to 74718	>74718
Aug	<=16653	16654 to 27355	27356 to 44799	44800 to 75591	>75591
Sep	<=16978	16979 to 27843	27844 to 45398	45399 to 76368	>76368

* Hydrologic condition limits are set by the historical record period as indicated. These limits will be applied over the life of the HCP to maintain consistency with effects analyses. Over time, and particularly with changing climate conditions, frequency of occurrence in each Category may diverge from historical frequencies.

Minimum instream flow targets are presented in the following sections in tables for each diversion (e.g. Table 4-2). Bypass flows are presented by month, life stage, and hydrologic condition. In any month, the bypass flow is driven by the life stage having the highest flow requirement. Rearing baseflows are provided when other life stages are not controlling. Flows for adult migration are provided when natural flow (i.e. without City diversions) would be at that level. Adult migration flows are presented as an upper and lower threshold with diversion halted when the lower threshold is reached and not resumed until natural flows exceed the upper threshold or recede below the lower threshold. Only the amount of flow in excess of the upper threshold is available for diversion. If flow drops below the lower threshold, the life stage with the next highest flow requirement would determine the minimum bypass level. Spawning flows are provided for a period of 14 days following the last occurrence of a migration flow. Incubation flows are provided for a period of 60 days following the last spawning flow or until May 31st, whichever occurs first. These general provisions may be relaxed in specific circumstances noted in the Tables. A more detailed description of the development and application of the bypass flows is provided in Appendix 9: *Rationale for Determining Minimum Instream Flow Targets*.

Liddell Spring Diversion

The Liddell Spring diversion may affect steelhead and coho by flow reduction that impairs ability of adult fish to migrate upstream in the winter and for smolts to migrate downstream in the spring; limits suitability of habitat for spawning, egg incubation, and juvenile rearing; reduces the productivity of benthic macro-invertebrates in the stream; and causes stranding, particularly of fry, when abrupt flow changes result from changes in diversion rates.

Restoration of flow in Liddell Creek was given lower priority than Laguna Creek and the San Lorenzo River due to limited productive capacity for steelhead, unsuitability of habitat for coho, relatively short anadromous length, and relatively small size of the diversion relative to Laguna Creek and the San Lorenzo River. Productive capacity is limited due to excessive amounts of fine sediment and lack of a functional lagoon (Chapter 2). A schedule of instream flow targets to minimize effects for the Liddell Spring Diversion under the HCP is presented in Table 4-2 and described as specific measures as follows.

Measure WS-1: Provide 0.25 cfs minimum bypass flow for rearing juvenile steelhead in Liddell Creek in the two driest hydrologic conditions (80%-100% exceedance and 60%-80% exceedance). A flow of 0.25 cfs provides approximately 27% of the maximum habitat index for steelhead rearing in the reach (HES 2014b).

Measure WS-2: Provide up to 5.2 cfs minimum bypass flow for rearing juvenile steelhead in the anadromous reach of Liddell Creek in normal, wet, and very wet hydrologic conditions (0%-60% exceedance). This provides approximately 76% of the maximum habitat index for steelhead rearing in the reach (HES 2014b).

Measure WS-3: Provide minimum bypass flows for adult migration in the anadromous reach in December through April of 0%-60% hydrologic conditions with a lower flow threshold of 4.9 cfs and an upper threshold of 11.3 cfs whenever flow would be at this level without City diversions.

Measure WS-4: Provide minimum bypass flows for spawning in the anadromous reach in December through May of 0%-60% hydrologic conditions of 7.4 cfs for 14 days following any adult migration period (provides estimated 80% of peak habitat index for steelhead spawning and 97% of the peak for coho).

Measure WS-5: Provide bypass flows for egg incubation in January through May of 0%-60% hydrologic conditions. The incubation flow in Liddell Creek is 2.0 cfs. Incubation flows are provided for 60 days after the last spawning day or until May 30, whichever is earliest.

Measure WS-6: Provide bypass flows for smolt migration in the anadromous reach during January through May in 0-60% hydrologic conditions (hydrologic conditions 1-3), and for at least 3 consecutive days per week in March, April, and May in 60%-100% conditions (hydrologic conditions 4 and 5). The smolt migration minimum is 2 cfs.

Measure WS-7: Implement a ramping rate during flow changes at Liddell Spring Diversion to limit flow reductions such that change in stage is no greater than 0.16 feet per hour when fry may be present (January 15 through May 31) and no greater than 0.3 feet per hour at other times.

The instream flow targets in Table 4-2 apply to the City maintained stream gage in the anadromous reach of Liddell Creek, a short distance upstream of Highway 1. The point of diversion is approximately 2 miles upstream of the anadromous gage and there is accretion of flows from other sources, including the Middle Branch and West Branch of Liddell Creek. There are also other diverters in the watershed, including the former CEMEX quarry, numerous wells in the recharge area for the creek, two alluvial wells near the confluence of the West and East Branches owned by the Bureau of Land Management and an agricultural diversion just upstream of Highway 1 (Chapter 2). The magnitude and timing of other diversions is not known with any certainty and cannot be predicted. The point of compliance is at the Anadromous Liddell gage; other gages will also be used to ascertain effects of these other diversions on flows and habitat availability in the anadromous reach.

Table 4-2: Minimum instream flow targets for avoidance and minimization of effects on steelhead due to the Liddell Spring Diversion

	Minimum Flow at Liddell Creek Anadromous Gage (cfs)								
	Rearing Base flow					Migration		Spawning	
	Hydrologic Condition 5 80-100% (driest)	Hydrologic Condition 4 60-80% (dry)	Hydrologic Condition 3 40-60% (normal)	Hydrologic Condition 2 20-40% (wet)	Hydrologic Condition 1 0-20% (very wet)	Adult[1]	Smolt[2]	Spawn[3]	Incubate[4]
Jan	0.25	0.25	2.9	3.6	4.7	4.9/11.3	2.0	7.4	2
Feb	0.25	0.25	4.6	3.9	5.1	4.9/11.3	2.0	7.4	2
Mar	0.25	0.25	3.5	4.8	5.2	4.9/11.3	2.0	7.4	2
Apr	0.25	0.25	3.0	4.3	4.6	4.9/11.3	2.0	7.4	2
May	0.25	0.25	2.6	3.3	4.0		2.0	7.4	2
June	0.25	0.25	2.0	2.4	2.9				
Jul	0.25	0.25	1.6	1.9	2.2				
Aug	0.25	0.25	1.4	1.7	1.8				
Sep	0.25	0.25	1.3	1.5	1.6				
Oct	0.25	0.25	1.5	1.5	1.6				
Nov	0.25	0.25	1.8	1.9	1.9				
Dec	0.25	0.25	2.1	2.6	3.0	4.9/11.3		7.4	

[1] Provided in 0%-60% hydrologic conditions only.

[2] Smolt migration flows provided in 0-60% (hydrologic conditions 1-3), and for 3 consecutive days per week in March, April, and May in 60%-100% (hydrologic conditions 4 and 5).

[3] 80% of peak steelhead spawning WUA for 14-day period after any potential migration event in 0-60% hydrologic conditions; not provided in 60-100% hydrologic conditions.

[4] Provided in 0-60% hydrologic conditions for 60-day period following occurrence of last spawning flow or May 30, whichever occurs first; not provided in 60-100% hydrologic conditions.

Reggiardo Creek Diversion

The Reggiardo Creek Diversion, while currently inoperable, historically diverted from 1.6-2.8 cfs continuously with conveyance through an 850 foot gravity pipeline to the Laguna Creek Diversion pond (Section 3.3.1). The Reggiardo Diversion is approximately 300 feet upstream of the confluence with Laguna Creek. As such, any effect of the Reggiardo Creek Diversion on species in the anadromous reach of Laguna Creek is incorporated in the operation of the Laguna Creek Diversion (see following section).

Laguna Creek Diversion

The Laguna Creek diversion may affect steelhead and coho by flow reduction that impairs ability of adult fish to migrate upstream in the winter and for smolts to migrate downstream in the spring; limits suitability of habitat for spawning, egg incubation, and juvenile rearing; degrades water quality conditions in the lagoon at the mouth of the creek; reduces the productivity of benthic macro-invertebrates in the stream; and causes stranding, particularly of fry, when abrupt flow changes result from changes in diversion rates.

The City/TAC has assigned Laguna Creek a high priority for restoration of flows relative to the other North Coast streams covered in this HCP due to underlying habitat conditions that have a higher potential to support recovery of salmonids. It is the largest watershed and has the longest reach of anadromous habitat of all the North Coast streams where the City diverts water. It also has a nearly intact lagoon system that can be very productive for steelhead. Laguna Creek also has the potential to support coho as evidenced by recent observations of juveniles there (Chapter 2). A schedule of instream flow targets to minimize effects of the Laguna/Reggiardo Diversion[45] under the HCP is presented in Table 4-3 and described as specific measures as follows.

Measure WS-8: Provide 2 cfs minimum bypass flow for rearing juvenile steelhead in the anadromous reach of Laguna Creek at all times. This is approximately the 44% exceedance flow for August in the historical hydrologic record and equates to about 70% of the maximum habitat index for steelhead rearing in August in the reach and approximately 99% of the maximum habitat index for coho rearing (HES 2014).

Measure WS-9: Provide minimum bypass flows for adult migration in the anadromous reach with a lower flow threshold of 10.6 cfs and an upper threshold of 15.5 cfs in December through March of all

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[45] Instream flow targets for the Reggiardo Diversion are included in the Laguna Creek bypass flow targets. The Reggiardo and Laguna Creeks Diversions operate in tandem and are miles above the Laguna Creek limit of anadromy. Therefore, they have a cumulative effect on anadromous reach flows.

hydrologic conditions and April when hydrologic condition is 0-60% whenever flow would be at this level without City diversions.

Measure WS-10: Provide minimum bypass flows for spawning in the anadromous reach of 9.4 cfs during December through May for 14 days following any adult migration period (providing 80% of peak habitat index for steelhead spawning and 97% of the peak for coho).

Measure WS-11: Provide bypass flows for egg incubation in January through May in all hydrologic conditions. The incubation flow in Laguna Creek is 4.0 cfs. Incubation flows are provided for 60 days after the last spawning day or until May 30, whichever is earliest.

Measure WS-12: Provide bypass flows for smolt migration in the anadromous reach during January through May in 0-80% hydrologic conditions (hydrologic conditions 1-4), and for at least 3 consecutive days per week in 80%-100% conditions (hydrologic condition 5). The smolt migration minimum is 3.8 cfs. For background on the various hydrologic conditions, see Appendix 8: Hydrologic, Water Supply, and Fisheries Habitat Effects Modeling.

Measure WS-13: Implement a ramping rate during flow changes at Laguna Creek Diversion to limit flow reductions such that change in stage is no greater than 0.16 feet per hour when fry may be present (January 15 through May 31) and no greater than 0.3 feet per hour at other times.

The instream flow targets in Table 4-3 apply to the City maintained stream gage in the anadromous reach of Laguna Creek, a short distance upstream of Highway 1. The point of diversion is approximately 4 miles upstream of the anadromous gage and there is accretion of flows from other sources, including Y Creek. Although the point of compliance is at the anadromous gage, other gages will also be used to ascertain effects of these other diversions on flows and habitat availability in the anadromous reach.

Table 4-3: Minimum Instream Flow Targets for Avoidance and Minimization of Effects on Steelhead Due to the Laguna Creek Diversion

	Minimum Flow at Laguna Creek Anadromous Gage (cfs)								
	Rearing Base flow					Migration		Spawning	
	Hydrologic condition 5 80-100% (driest)	Hydrologic condition 4 60-80% (dry)	Hydrologic condition 3 40-60% (normal)	Hydrologic condition 2 20-40% (wet)	Hydrologic condition 1 0-20% (very wet)	Adult	Smolt Migration[1]	Spawn[2]	Incubate[3]
Jan	2	2	2	2	2	11.3/15.5	3.8	9.4	4
Feb	2	2	2	2	2	11.3/15.5	3.8	9.4	4
Mar	2	2	2	2	2	11.3/15.5	3.8	9.4	4
Apr	2	2	2	2	2	11.3/15.5[4]	3.8	9.4	4
May	2	2	2	2	2		3.8	9.4	4
June	2	2	2	2	2				
Jul	2	2	2	2	2				
Aug	2	2	2	2	2				
Sep	2	2	2	2	2				
Oct	2	2	2	2	2				
Nov	2	2	2	2	2				
Dec	2	2	2	2	2	11.3/15.5		9.4	

[1] Smolt migration flows shall be provided in 0-80% (hydrologic conditions 1-4), and for 3 consecutive days per week in 80%-100% (hydrologic condition5) in March, April, and May.

[2] 80% of peak steelhead spawning WUA for 14-day period after any potential migration event.

[3] For 60-day period following occurrence of last spawning flow or May 30, whichever occurs first.

[4] April adult migration flows provided in 0-60% exceedance conditions/hydrologic conditions 1-3.

Majors Creek Diversion

The Majors Creek diversion may affect steelhead and coho by flow reduction that impairs ability of adult fish to migrate upstream in the winter and for smolts to migrate downstream in the spring; limits suitability of habitat for spawning, egg incubation, and juvenile rearing; reduces the productivity of benthic macro-invertebrates in the stream; and causes stranding, particularly of fry, when abrupt flow changes result from changes in diversion rates.

Restoration of flow in Majors Creek was given lower priority than Laguna Creek and the San Lorenzo River due to the short anadromous reach length (0.6 miles) and lack of a developed lagoon (Chapter 2). It also has a relatively small diversion capacity (2.1 cfs) relative to Laguna Creek (6.3 cfs) and the San Lorenzo River at the Tait Street Diversion (12.2 cfs). A schedule of instream flow targets to minimize effects of the Majors Creek diversion under the HCP is presented in Table 4-4. Comparisons of actual habitat values that would occur under HCP flows are provided in Chapter 5.

Measure WS-14: Provide 0.25 cfs minimum bypass flow for rearing juvenile steelhead in Majors Creek in the two driest hydrologic conditions (80%-100% and 60%-80%). A flow of 0.25 cfs equates with approximately 27% of the maximum WUA for rearing juvenile steelhead occurring in Majors Creek.

Measure WS-15: Provide up to 4.7 cfs minimum bypass flow for rearing juvenile steelhead in the anadromous reach of Majors Creek in normal, wet, and very wet hydrologic conditions (0%-60%). This is more than the maximum August flow and approximately the 10% exceedance flow for June in the historical hydrologic record and equates to about 86% of the maximum habitat index for steelhead in June (HES 2014b).

Measure WS-16: Provide minimum bypass flows for adult migration in the anadromous reach in December through April of 0%-60% hydrologic conditions with a lower flow threshold of 9 cfs and an upper threshold of 16 cfs whenever flow would be at this level without City diversions.

Measure WS-17: Provide minimum bypass flows for spawning in the anadromous reach in December through May of 0%-60% hydrologic conditions of 12.1 cfs for 14 days following any adult migration period (provides estimated 80% of peak habitat index for steelhead spawning and 97% of the peak for coho).

Measure WS-18: Provide bypass flows for egg incubation in January through May of 0%-60% hydrologic conditions. The incubation flow in Majors Creek is 2.9 cfs. Incubation flows are provided for 60 days after the last spawning day or until May 30, whichever is earliest.

Measure WS-19: Provide bypass flows for smolt migration in the anadromous reach during January through May in 0-60% hydrologic conditions (hydrologic conditions 1-3), and for at least 3 consecutive days per week in March, April, and May in 60%-100% conditions (hydrologic conditions 4 and 5). The smolt migration minimum is 3.4 cfs.

Measure WS-20: Implement a ramping rate during flow changes at Majors Creek Diversion to limit flow reductions such that change in stage is no greater than 0.16 feet per hour when fry may be present (January 15 through May 31) and no greater than 0.3 feet per hour at other times.

The instream flow targets in Table 4-4 apply to the City-maintained stream gage in the anadromous reach of Majors Creek, immediately upstream of Highway 1. The point of diversion is approximately 2 miles upstream of the anadromous gage and there is accretion of flows in the intervening reach. There are at least four known non-City operated diversions on Majors Creek (ENTRIX, Inc. 2004c), including three diversions operated by Edwards, two of which are located in the anadromous reach just upstream of the Highway 1 crossing. There are also several diversions upstream of the City diversion (Chris Berry, personal communication to Kindra Loomis, 2004, cited in ENTRIX, Inc. 2004c). Production numbers and season of diversion for the non-City diversions are unavailable and their impacts on Majors Creek hydrology are unclear. The point of compliance is at the anadromous gage; other gages will also be used to ascertain effects of other diversions on flows and habitat availability in the anadromous reach.

Table 4-4: Minimum Instream Flow Targets for Avoidance and Minimization of Effects on Steelhead Due to the Majors Creek Diversion

	Minimum Flow at Majors Creek Anadromous Gage (cfs)								
	Rearing Base flow					Migration		Spawning	
	Hydrologic condition 5 80-100% (driest)	Hydrologic condition 4 60-80% (dry)	Hydrologic condition 3 40-60% (normal)	Hydrologic condition 2 20-40% (wet)	Hydrologic condition 1 0-20% (very wet)	Adult[1]	Smolt[2]	Spawn[3]	Incubate[4]
Jan	0.25	0.25	2.2	2.7	4.1	9/16	3.4	12.1	2.9
Feb	0.25	0.25	4.1	3.0	4.4	9/16	3.4	12.1	2.9
Mar	0.25	0.25	2.4	4.3	4.7	9/16	3.4	12.1	2.9
Apr	0.25	0.25	1.7	3.1	3.2	9/16	3.4	12.1	2.9
May	0.25	0.25	1.4	1.8	2.4		3.4	12.1	2.9
June	0.25	0.25	1.0	1.2	1.6				
Jul	0.25	0.25	0.8	1.0	1.1				
Aug	0.25	0.25	0.7	0.8	0.9				
Sep	0.25	0.25	0.6	0.7	0.7				
Oct	0.25	0.25	0.8	0.9	0.8				
Nov	0.25	0.25	1.1	1.2	1.2				
Dec	0.25	0.25	1.5	1.9	2.1	9/16		12.1	

[1] Provided in 0%-60% hydrologic conditions only.

[2] Smolt migration flows provided in 0-60% (hydrologic conditions 1-3), and for 3 consecutive days per week in March, April, and May in 60%-100% (hydrologic conditions 4 and 5).

[3] 80% of peak steelhead spawning WUA for 14-day period after any potential migration event in 0-60% hydrologic conditions; not provided in 60-100% hydrologic conditions.

[4] Provided in 0-60% hydrologic conditions for 60-day period following occurrence of last spawning flow or May 30, whichever occurs first; not provided in 60-100% hydrologic conditions.

Newell Creek Diversion

Operation of Loch Lomond Reservoir and the Newell Creek Diversion alters the natural hydrograph of Newell Creek except during periods when the reservoir is spilling. During non-spill periods flow reduction may impair the ability of adult fish to migrate upstream in the winter and for smolts to migrate downstream in the spring; limit the suitability of habitat for spawning, egg incubation, and juvenile rearing; reduce the productivity of benthic macro-invertebrates in the stream. There are generally not abrupt changes in flow since the creek is either influenced by the 1 cfs minimum release or the natural pattern of reservoir spill. The presence of Newell Creek Dam also prevents transport of sediment and LWD potentially impairing the recruitment of spawning gravels and LWD as a source of potential cover (Holley 2010). While these effects cannot be avoided or minimized, they can be mitigated under the non-flow conservation fund (Section 4.5) through programs such as gravel replenishment and LWD placement.

Management actions to replace spawning gravels may improve conditions but would not be naturally sustainable as the smaller gravels would be transported downstream and not replaced from upstream. Only a sustained effort to replace gravel could improve conditions indefinitely. Wherever possible bank protection measures should be restricted to allow lateral migration of the creek. Incised channels should be allowed to evolve into a more stable stage where the creek is free to erode banks and migrate within its floodplain, actively recruiting LWD. Management actions that include adding LWD to the stream could help to create scour pools where LWD recruitment is limited by riparian encroachment by development or immature vegetation. The most immediate and effective action to improve salmonid habitat is to stop removal of LWD in the channel. Evidence of large logs being removed from the channel can be seen in all reaches (Holley 2010).

Passage above Newell Dam is not part of the HCP because passage conditions downstream of the dam are marginal and, even if fish could routinely pass the bedrock chute identified as the current limit of anadromy, bathymetry studies of the reservoir indicate that anadromy likely historically ended at a very steep reach of channel that is now beneath the reservoir (located close to the dam). Thus, the reservoir does not impede passage to significant amounts of historic above-reservoir habitat.

Streamflows

Standard facility operations related to the City’s water right for Newell Creek (license # 9847) include a year-round minimum release requirement of 1 cfs below Newell Creek Dam. During the fully appropriated season, the license requires that the greater of 1 cfs or the natural flow of Newell Creek must be released.

Restoration of flow in Newell Creek was given lower priority than Laguna Creek and the San Lorenzo River. The anadromous reach length is relatively short and habitat conditions in the majority of the anadromous reach are degraded due to close proximity of residential development on both sides of the creek (Chapter 2). Providing flow for migration and spawning would severely constrain storage in the reservoir and increase reliance on other diversions. Adult migration, spawning, incubation, and smolt migration bypass flows have not been specified for Newell Creek however flows sufficient for these uses occur during periods of reservoir spill. Existing agreements attached to the aforementioned water right specify a minimum bypass flow of 1 cfs at all times.

Hydrologic modeling indicates that the operation of the reservoir results in a slight reduction in median flows through the anadromous reach (compared to reservoir inflows) during the early part of the spring rearing period in wet, normal and dry years, and an augmentation of median flows during the latter part of the rearing period due to the 1 cfs minimum release (ENTRIX, Inc. 2004c). Flow augmentation is highest (begins earlier) in dry years, and lowest in wet years. During critical dry years, the 1 cfs release requirement augments the natural flow throughout the rearing period and essentially doubles the flow downstream of the dam relative to median reservoir inflow from July through October.

Since the 1 cfs minimum release is above unimpaired levels at certain times and in order to preserve storage in Loch Lomond Reservoir an exception minimum of 0.25 cfs would be instituted when storage is low enough to result in supply shortages (Table 4-5). PHABSIM model results indicate that the habitat suitability index for rearing steelhead at 0.25 cfs is 70% of the value at 1.0 cfs (HES 2014b). The City, in consultation with NMFS and CDFW, implemented a release of 0.2 cfs during recent drought conditions from February 2014 to February 2016 under a Temporary Urgency Change Petition with the State Water Resources Control Board. The 0.2 cfs flow level (68% of the habitat index at 1.0 cfs flow) provided reasonable habitat conditions during that period based on observations made by the City Water Department and reviewed by NMFS and CDFW (Chris Berry, personal communication to Jeff Hagar, 2014). Provision of a slightly higher flow during exception years in the future should ensure that this continues to be the case. Exception minimum flows would be provided when Loch Lomond Reservoir storage falls below the following storage conditions:

Table 4-5: Storage Conditions in Loch Lomond Reservoir Triggering Exception Minimum Flows

	Minimum storage for 1 cfs release (mg)	Percent of Capacity
Nov	1,500	53%
Dec	1,700	60%
Jan	2,000	70%
Feb	2,000	70%
Mar	2,000	70%
Apr	2,000	70%
May	2,000	70%
June	2,000	70%
Jul	1,800	64%
Aug	1,500	53%
Sep	1,500	53%
Oct	1,500	53%

In Confluence modeling results for the proposed Water Rights Project, exception minimum flows would be applied in portions of 9 years (27 out of 948 months or 3% of the time) during the 79-year model period. This compares with modeled existing demand and infrastructure with interim bypass flows (2018 tolling agreement flows before HCP agreed flows are in place) predicting exception minimum flows during 87 months (9% of the time) in portions of 16 years. Duration of exception minimum flows was between 1 and 5 months for the proposed project except for one model year (1977) with 12 months. Exception minimum flows are primarily imposed during October through April and are most frequent in December and January. The exception minimum flows would most likely be implemented in Newell Creek in years when there has been no spill. Adult migration and spawning are less likely to occur in the absence of higher flows that result from spill conditions and rearing abundances are therefore likely to be lower. Comparisons of actual habitat values that would occur under HCP flows are provided in Chapter 5. Model results show that, even with the exception minimum flows, the 1 cfs bypass flow requirement at Newell Creek Dam provides improved summer rearing habitat value as compared to no City diversion in all hydrologic year types (Chapter 5). The base hydrology (no diversion) shows 31 years with flow less than 0.33 cfs below Newell Creek Dam during portions of the June through October period (24% of the time during this period overall). The 1 cfs instream flow requirement also results in flow augmentation in the main stem San Lorenzo River downstream of Newell Creek, although the proportional increase is much smaller. A schedule of instream flow targets to minimize effects of the Newell Creek Diversion under the HCP is presented in Table 4-6.

Water Temperature

Due to the presence of the reservoir, temperature in Lower Newell Creek below the dam is warmer than Upper Newell Creek during winter and spring and cooler in the summer by up to 4°C on average (Section 2.4.3.2). Warmer water in the spring can enhance salmonid growth rates if food resources are sufficient. The cooling influence in summer can extend downstream as far as the San Lorenzo River (City of Santa Cruz monitoring data, HES 2014b). Although the cooling influence in summer may depress growth rates, this effect would be strongest closest to the dam.

Reservoir spill can result in increased temperature downstream of the dam during periods when the reservoir surface temperature is high. The majority of spill occurs during or after precipitation events in the winter when Loch Lomond temperature is cool. The period when temperature effects are most likely is during the spring and early summer (May through July) when the lake surface is warming and there is still a potential for spill, at least in wetter years when storage is high. Potential effects on steelhead and coho can be avoided by ensuring that sufficient cool water is released through the fish release to blend with and moderate warm flows through the spillway (Measure WS-24).

Measures for avoiding and minimizing the effect of Loch Lomond Reservoir operations on habitat for Covered Species in Newell Creek include the following:

Measure WS-21: Provide 0.25 cfs minimum bypass flow for rearing juvenile steelhead in the anadromous reach of Newell Creek when Loch Lomond Reservoir storage is less than specified storage levels (Table 4-5).

Measure WS-22: Provide 1 cfs minimum bypass flow for rearing juvenile steelhead in the anadromous reach of Newell Creek at all other times.

Measure WS-23: During changes in bypass rates downstream of Newell Creek Dam, a ramping rate will be implemented to limit flow reductions in Newell Creek such that the change in stage is no greater than 0.16 feet per hour when fry may be present (January 15 through May 31) and no greater than 0.3 feet per hour at all other times.

Measure WS-24: At times when the Loch Lomond Reservoir is spilling during late spring and summer when surface temperatures in the reservoir are warmer and the cooler 1 cfs fish release below the dam (generally between 11°C and 14°C) may not be sufficient to maintain temperature in Newell Creek below 21°C, which is within the suitable range for steelhead and coho salmon, the City will release additional flow through the fish release to achieve a maximum instantaneous temperature of less than 21°C as measured in the anadromous reach of Newell Creek and verified at the City stream gage in Newell Creek below the dam. The point of compliance for minimum bypass flows is the City maintained stream gauge in Newell Creek immediately downstream of Newell Creek Dam.

Table 4-6: Minimum Instream Flow Targets for Avoidance and Minimization of Effects on Steelhead Due to the Newell Creek Diversion

		Minimum Flow at Newell Creek below Dam (cfs)								
		Rearing Baseflow					Migration		Spawning	
	Exception Minimum	Hydrologic Condition 5 80-100% (driest)	Hydrologic Condition 4 60-80% (dry)	Hydrologic Condition 3 40-60% (normal)	Hydrologic Condition 2 20-40% (wet)	Hydrologic Condition 1 0-20% (very wet)	Adult	Smolt Migration	Spawn	Incubate
Jan	0.25	1.0	1.0	1.0	1.0	1.0				
Feb	0.25	1.0	1.0	1.0	1.0	1.0				
Mar	0.25	1.0	1.0	1.0	1.0	1.0				
Apr	0.25	1.0	1.0	1.0	1.0	1.0				
May	0.25	1.0	1.0	1.0	1.0	1.0				
June	0.25	1.0	1.0	1.0	1.0	1.0				
Jul	0.25	1.0	1.0	1.0	1.0	1.0				
Aug	0.25	1.0	1.0	1.0	1.0	1.0				
Sep	0.25	1.0	1.0	1.0	1.0	1.0				
Oct	0.25	1.0	1.0	1.0	1.0	1.0				
Nov	0.25	1.0	1.0	1.0	1.0	1.0				
Dec	0.25	1.0	1.0	1.0	1.0	1.0				

Felton Surface Water Diversion at San Lorenzo River

Operation of the Felton Diversion potentially influences sediment transport, fish passage, and streamflow in the San Lorenzo River. Constraints on operation of the Felton Diversion under existing agreements and planned upgrades avoid and minimize effects of this activity to migration, spawning, and rearing of Covered Species.

Sediment Transport

Sediment may collect behind the dam during periods when the dam is inflated and be released when the dam is deflated. The following measures are adapted from current SOPs for the dam and will result in minor alterations to storm hydrographs due to facility operations and avoid any potential effects on sediment transport:

Measure WS-25: Deflate dam during the first one or two rainstorms of the season to flush sediments and organic matter from the channel.

Measure WS-26: Deflate dam during high flows when the majority of sediment is being transported.

Fish Passage

Under the 1998 MOA with CDFW (Chapter 3), operations are managed to allow adult steelhead and coho to migrate upstream. Operations are based on streamflow conditions during winter months and include specific operational changes based on low, moderate, and high streamflow conditions as outlined below. The following measures maintain the provisions of the 1998 MOA but are altered to accommodate new winter bypass flows for adult migration and spawning.

Measure WS-27: During November 1 through March 31 when the mouth of the San Lorenzo River is open and streamflow is less than 40 cfs and the City is diverting water, the dam will be inflated to allow 20 cfs bypass flow through the fish ladder. During the same period, if the City is not diverting, the City will inflate small air bladders beneath the deflated dam or employ similar, comparable measures for the purpose of facilitating fish passage over or around the facility. If passage over the deflated dam is provided, the depth of flow within the zone of concentrated flow crossing the dam will be 8 inches or greater. Similarly, if passage is provided around the dam through the pumping channel, 8 inches of depth or greater will be provided.

Measure WS-28: During December 1 through April 30 when the mouth of the San Lorenzo River is open and streamflow is 40 cfs or more configure the dam to bypass 40 cfs with a minimum of 20 cfs through the fish ladder.

Measure WS-29: For moderate streamflow conditions, during November 1 through March 31 when the mouth of the San Lorenzo River is open and streamflows are between 40 and 200 cfs, the City will divert water by inflating the dam and allowing a minimum 40 cfs bypass flow. During these moderate streamflow conditions, the City will keep the dam deflated during the first one or two rainstorms to flush sediments and organic matter from the channel. During these conditions of winter operation, migrating fish can pass over the deflated dam.

Measure WS-30: In high streamflow conditions (exceeding 200 cfs) from November 1 through March 31, when the City is diverting, the dam will be inflated such that the fish ladder is operational. When streamflow exceeds approximately 300 cfs, the slide gate on the fish ladder will be opened approximately 8 inches to increase attraction flow to the ladder entrance. When streamflows have equaled or exceeded 300 cfs for five consecutive days and adult steelhead or salmon are observed holding downstream of the dam, on the following day the dam will be partially deflated and the slidegate closed in the evening and overnight. This allows the steelhead and salmon the opportunity to jump and swim over the partially deflated dam. When streamflows exceed 2,000 cfs the City will fully deflate the dam.

The Felton Diversion intake is screened and provides adequate average approach and sweeping velocities, although it does not meet all current NMFS criteria for screen openings, cleaning frequency and bypass systems (Borcalli and Associates 2001). The City operates under specific BMPs for fish ladder and fish screen maintenance (see Section 4.4.3.2) and those measures are incorporated here as well.

Measure WS-31: Inspect fish ladder 2-3 times per week and manually clean and remove debris as needed. Remove debris from site and dispose at approved waste disposal facility.

Measure WS-32: Inspect all fish screens regularly (daily) and manually clean and remove debris from screens and debris racks as needed.

Measure WS-33: Upon implementation of the proposed Santa Cruz Water Rights Project (as described in Section 6.2.1), the City will undertake a facility upgrade at the Felton Diversion. Planning for the facility upgrade will include a comprehensive evaluation of existing fish migration conditions at the facility and potential improvements for upstream and downstream migration of both juvenile and adult steelhead. Findings of this evaluation will be used to design state of the art fish passage components that may include revisions to the pumping channel, the Denil fish ladder, or both. The evaluation will consider the potential for channel changes downstream of the diversion and revisions will be designed to accommodate possible channel changes. Any revisions based on these findings will be incorporated in the upgrade project. The upgrade will include screen replacement, continuous cleaning system, and juvenile passage modifications to meet current fish screen and fish passage criteria. The fish screen material will be replaced with either wedge wire with a 1.75 mm slot width or a perforated plate with 3/32” diameter perforations. A mechanical traveling brush system will be installed for continuous screen cleaning. The brush system will provide a 5-minute continuous cleaning cycle. A continuous bypass route will be installed so that out-migrants entrained in the intake structure can continue their movement downstream. Ladder upgrades to improve passage will be evaluated and incorporated as appropriate as well.

These measures will be incorporated into future operations of the Felton Diversion Dam and together with planned facility upgrades will fully avoid the effects of facility operation on migration of Covered Species.

Streamflows

Diversion of flow at the Felton Diversion Dam potentially influences migration, spawning, and rearing of Covered Species in downstream reaches. Current agreements specify diversion rates and bypass flows to minimize these potential effects. In addition, new bypass flows for adult migration and spawning have been adopted under the HCP based on recent information provided by Berry (2016).

Berry (2016), using the R2 approach (see Section 2.4.3.1 under Instream Habitat, Migration Barriers), estimated that a flow of 39 cfs appears to be a reasonable adult migration flow estimate for the San Lorenzo River below the Felton Diversion (Chapter 2). This estimate was vetted with NMFS and CDFW in meetings of the technical review team and it was decided that bypass flows for the Felton Diversion would be determined consistent with the other diversions (HCP Technical Team Draft Minutes, 12/13/2016; HCP Technical Team Meeting #5 Minutes 1/17/2017). Specifically, 40 cfs would be used as the adult migration minimum and would be provided whenever it would occur in the absence of the diversion. Optimum spawning flows are typically slightly below migration flows and are provided for two weeks following the most recent occurrence of migration flows. Rearing flows are usually on the order of about half of migration flow levels. These flows are generally consistent with data and recommendations provided in Ricker and Butler (1979) and HES (2014) (Chapter 2).

The 40 cfs bypass flow for adult migration (rounded up from 39 cfs) will be extended to provide for spawning for 14 days after potential passage events. The existing winter bypass flow of 20 cfs is half the recommended adult migration flow and is consistent with the proportional relationship between optimum rearing flow and adult migration flow derived through PHABSIM studies in other streams (Section 2.4.3.1, HES 2014b). This bypass flow regime should also be protective of incubation and smolt migration based on these same results. A schedule of instream flow targets to minimize effects of the Felton Diversion under the HCP is presented in Table 4-7 and described as specific measures as follows.

Raising and lowering of the Felton Diversion Dam has the potential to result in stage changes in the San Lorenzo River downstream of the dam. The Dam may be raised or lowered at flows up to 2,000 cfs but must be fully deflated at flows above 2,000 cfs. The HCP has adopted criteria for levels of stage change at North Coast diversions that are protective of juvenile salmonid life stages based on review of the literature and standards developed by fisheries resource Agencies (Hagar 2014). The criteria call for change in stage no greater than 0.16 feet per hour when fry may be present (January 15 through May 31) and no greater than 0.3 feet per hour at all other times. However, the San Lorenzo River at Felton exhibits rapid changes in stream flow and stage under winter storm flow conditions that can exceed those criteria. The greatest changes in stage occur at flows over 2,000 cfs. Still, stage changes during storm flows less than 2,000 cfs, even without operation of the diversion dam, can exceed established criteria. For example, during the winter of 2016-2017 when the diversion dam was not operated and rainfall and streamflow was above normal, stage change during the ascending limb of the hydrograph (increasing flows) at flows less than 2,000 cfs peaked at 1.68 feet per hour during storm flows and exceeded 0.30 feet per hour on 195 occasions during 23 days between December and April (USGS streamflow monitoring data for the San Lorenzo River at Big Trees gage, located just downstream of the Felton Diversion). Stage declines ranged as high as -0.55 feet per hour during the descending limb of the hydrograph (decreasing flow) and exceeded -0.30 feet per hour on 42 occasions and exceeded -0.16 feet per hour on 178 occasions during 14 days between December and April. Stage decrease is more of a concern than stage increase for juvenile salmonids because of the potential to strand sensitive life-stages in areas of the channel margin that are relatively low-gradient, or where pockets or side channels exist in the stream channel.

Existing MOAs for operation of the Felton Diversion and new bypass flows for migration and spawning are incorporated into the following measures that fully avoid effects to Covered Species from diversion related flow changes below the Felton Diversion.

Measure WS-34: Do not divert at the Felton Diversion during June through August.

Measure WS-35: Provide 20 cfs minimum bypass flow for rearing and smolt migration during November 1 through May 31 in all hydrologic categories.

Measure WS-36: Provide 10 cfs minimum bypass flow during September and 25 cfs minimum bypass in October in all hydrologic categories.

Measure WS-37: Provide 40 cfs minimum bypass flow for adult migration in December through April whenever natural flow would occur at this level in the absence of a diversion.

Measure WS-38: Provide 40 cfs minimum bypass flow for spawning in December through April for 14 days after potential passage events (i.e. 40 cfs flow and mouth of the river is open).

Measure WS-39: The City will manage inflation and deflation of the Felton Diversion Dam to maintain stage increase of less than 1.68 feet per hour during deflation of the dam and stage decrease of no more than -0.55 feet per hour during inflation of the dam. This will be accomplished through manual operation of the dam bladders by a trained operator. Inflation and deflation of the dam in response to anticipated changes in the hydrograph from forecast storms will be planned in advance in consultation with staff hydrologists to minimize stage changes to the maximum extent practicable.

Table 4-7: Minimum Instream Flows for Avoidance and Minimization of Effects on Steelhead and Coho due to Operation of the Felton Diversion

	Minimum Flow below the Felton Diversion (cfs)								
	All Life Stages					Migration		Spawning	
	Hydrologic Condition 5 80-100% (driest)	Hydrologic Condition 4 60-80% (dry)	Hydrologic Condition 3 40-60% (normal)	Hydrologic Condition 2 20-40% (wet)	Hydrologic Condition 1 0-20% (very wet)	Adult[1]	Smolt Migration	Spawn[2]	Incubate
Jan	20	20	20	20	20	40		40	
Feb	20	20	20	20	20	40		40	
Mar	20	20	20	20	20	40		40	
Apr	20	20	20	20	20	40		40	
May	20	20	20	20	20			40	
June	No Diversion								
Jul									
Aug									
Sep	10	10	10	10	10				
Oct	25	25	25	25	25				
Nov	20	20	20	20	20				
Dec	20	20	20	20	20	40		40	

[1] Provided in all hydrologic conditions when mouth has been open and natural flow would occur at this level without diversion.
[2] Provided for 14 days following any potential migration event.

Tait Street Diversion and Wells

The primary potential effects on steelhead and coho from the Tait Street Diversion are related to deterioration of migration and rearing habitat from reduction instream flow. At most times, except when water quality is poor during storm runoff periods, the City relies on the full amount of the diversion authorization. It is assumed that maximum diversion rate capacity for the diversion, as modified under the proposed Santa Cruz Water Rights Project, will remain unchanged over the period of the HCP.

The Tait Street Diversion dam and screens also potentially influences fish passage though no issues with either delay of adult upstream migration, juvenile migration, or entrainment or impingement of juveniles have been noted.

The Tait Street diversion neither creates nor discharges sediments. In the reach of river where the facility is located, the predominant substrate is sand. During high flows, suspended sediments and bedload pass the facility relatively unobstructed. Some sand, entrained by the inflow to the pumps, settles in a chamber before the pumps and is later removed by suction to the parking lot. Water from this process is allowed to flow back to the river downstream of the diversion (Section 4.4.3.3).

Fish Passage

The Tait Street Diversion is a run-of-river facility without a ladder. Juvenile fish can currently swim through holes in the diversion dam. Migrating fish can swim past the intakes or over the dam in the main channel at moderate to high flows. At lower flows, a moderate jump is required to pass this facility (Jon Jankovitz, CDFW, personal communication to Chris Berry, 2020). Although no issues related to the intake fish screens have been identified, the City will undertake a facility upgrade at the Tait Street Diversion to meet current fish screen criteria during the term of the HCP.

Measure WS-40: Modify the Tait Street Diversion to prevent entrainment and impingement and provide bypass per criteria issued by NMFS and/or CDFW. This may include: screens aligned parallel to river flow and composed of either perforated plate with screen openings not exceeding 3/32 inches (2.38 mm), measured in diameter; profile bar with screen openings not exceeding 0.0689 inches (1.75 mm) in width; or woven wire with screen openings not exceeding 3/32 inches (2.38 mm), measured diagonally (e.g. 6-14 mesh). Screen material shall provide a minimum of 27% open area. The screen material shall be corrosion resistant and sufficiently durable to maintain a smooth and uniform surface with long-term use. Design features will also include: uniform flow across the screens; approach velocities not exceeding 0.33 f/s; sweeping velocities that exceed approach velocities; provision for appropriate juvenile bypass; and provision for continuous cleaning. Fish Screens shall be automatically cleaned as frequently as necessary to prevent accumulation of debris. Open channel intakes shall include a trash rack in the screen facility design which shall be kept free of debris. In certain cases, a satisfactory profile bar screen design can substitute for a trash rack. The head differential to trigger screen cleaning for intermittent type systems shall be a maximum of 0.1 feet (0.03 m), unless otherwise agreed to by NMFS. It should be noted that, because the Tait Street Diversion currently has a "drum" type screen, the alternative CDFW/NOAA criteria for diversions under 40 cfs may apply. Final retrofit will be determined pending ongoing feasibility studies. Additionally, a feasibility analysis for horizontal wells, which also will prevent take of listed salmonids at this location, is also ongoing. Upgrades to improve passage will be evaluated and incorporated as appropriate.

In addition to this measure, the City operates under specific BMPs for fish ladder and fish screen maintenance (see Section 4.4.3.2). These measures, together with planned facility upgrades and bypass flow provisions, will avoid the effects of facility operation on migration of Covered Species.

Stream flows

Diversion of flow at the Tait Street Diversion potentially influences migration and rearing of Covered Species in downstream reaches. There is no suitable spawning habitat downstream of the Tait Street Diversion for either steelhead or coho. Rearing habitat is present for steelhead but is too warm for coho.

The San Lorenzo River is a high priority for restoration. It is a large watershed with extensive anadromous habitat (approximately 26 miles of anadromous habitat in the mainstem and 57 miles in the tributaries) (ENTRIX, Inc. 2004b). The San Lorenzo River supports steelhead and potentially supports coho. Although the lagoon is highly altered from pre-development conditions and the habitat is significantly degraded, it is still important for rearing juvenile steelhead (Chapter 2).

The strategy for streamflow restoration below Tait Street emphasized improving rearing conditions, particularly as inflow to the lagoon during the summer. This entails preserving storage in Loch Lomond Reservoir to support reduced summer diversions, particularly in drier years. As a result, winter bypasses for adult migration were more limited, also in part since ample opportunities for migration could still be achieved. A schedule of instream flow targets to minimize effects of the Tait Street Diversion under the HCP is presented in Table 4-8 and described as specific measures as follows.

Measure WS-41: Provide 8 cfs minimum bypass flow for rearing juvenile steelhead and lagoon inflows in the San Lorenzo River below the Tait Street diversion in dry and very dry hydrologic conditions (Table 4-8) This is approximately 60% of the maximum habitat index for steelhead rearing in the reach (HES 2014b).

Measure WS-42: Provide up to 18 cfs minimum bypass flow for rearing juvenile steelhead in the San Lorenzo River below the Tait Street diversion and for inflow to the lagoon in normal, wet, and very wet hydrologic conditions (Table 4-8). This is approximately 80% of the maximum habitat index for steelhead rearing in the reach (HES 2014b).

Measure WS-43: Provide minimum bypass flows for adult migration downstream of Tait Street with a lower flow threshold of 17 cfs and an upper threshold is 25.2 cfs in December through March of dry and very dry years. Adult migration bypass flows are to be provided whenever flow would be at this level without City diversions and when storage in Loch Lomond Reservoir is sufficient (Table 4-8), otherwise provide bypass flow for 3 consecutive days per week or 5 consecutive days depending on Loch Lomond Reservoir storage levels (Table 4-8).

Measure WS-44: Provide minimum bypass flows for adult migration downstream of Tait Street with a lower flow threshold of 17 cfs and an upper threshold is 25.2 cfs in December through April of normal, wet, and very wet years whenever flow would be at this level without City diversions (Table 4-8).

Measure WS-45: Provide minimum smolt migration flows of 10 cfs during January through May in dry, normal, wet, and very wet hydrologic conditions, and for at least 3 consecutive days per week in very dry conditions during March through May (Table 4-8). If the City determines that conditions will require diversion of stored water from Loch Lomond Reservoir that cannot be offset by diversions at Felton, or from Liddell and Majors Creeks, the City may further reduce smolt outmigration requirements at the Tait Street Diversion provided that: (a) drought has been officially declared; and (b) this reduction in smolt outmigration opportunities will not reduce smolt migration more than one full day/week in the lower San Lorenzo River system or there is evidence from the San Lorenzo River or neighboring watersheds (i.e. Scott Creek) indicating that smolt migration is no longer occurring.

Measure WS-46: Implement a ramping rate during flow changes at the Tait Street Diversion to limit flow reductions such that change in stage is no greater than 0.16 feet per hour when fry may be present (January 15 through May 31) and no greater than 0.3 feet per hour at other times.

The point of compliance for these flows is the City maintained stream gage immediately downstream of the Tait Street Diversion. Tributaries contribute additional flow below the diversion though this contribution is limited, particularly in the dry season. These include Pogonip Creek, Branciforte Creek, Pasatiempo Creek, Arroyo de San Pedro Regaldo, and Ocean Villa Creek.

Table 4-8: Minimum Instream Flows for Avoidance and Minimization of Effects on Steelhead and Coho Due to Operation of the Tait Street Diversion

	Minimum Flow in the San Lorenzo River below Tait Street (cfs)								
	Rearing Baseflow					**Migration**		**Spawning**[1]	
	Hydrologic condition 5 80-100% (driest)	**Hydrologic condition 4 60-80% (dry)**	**Hydrologic condition 3 40-60% (normal)**	**Hydrologic condition 2 20-40% (wet)**	**Hydrologic condition 1 0-20% (very wet)**	**Adult**[2]	**Smolt Migration**[3]	**Spawn**	**Incubate**
Jan	8	8	15.8	16.4	17.5	17/25.2	10		
Feb	8	8	15.9	16.7	18.0	17/25.2	10		
Mar	8	8	16.3	17.3	18.2	17/25.2	10		
Apr	8	8	17.2	17.9	18.4	17/25.2[4]	10		
May	8	8	17.7	18.2	18.5		10		
Jun	8	8	16.6	18.1	18.5				
Jul	8	8	12.4	15.8	18.2				
Aug	8	8	9.8	11.9	16.4				
Sep	8	8	9.0	11.1	13.3				
Oct	8	8	9.8	11.4	13.3				
Nov	8	8	12.5	14.1	16.4				
Dec	8	8	15.1	16.2	17.6	17/25.2			

[1] No spawning occurs in this reach.

[2] Adult migration flows may be reduced to 3 consecutive days a week if storage levels in Loch Lomond Reservoir fall below the following levels (MG): Dec-1900 MG; Jan-2,000 MG; Feb-2,100 (MG); Mar-2,200 (MG). Further, adult migration flows may be reduced to 5 consecutive days after each storm event that exceeds 17 cfs if storage levels in Loch Lomond Reservoir fall below the following levels: Dec-1600 (MG); Jan-1700 (MG); Feb-1800 (MG); Mar-1900 (MG).

[3] During critically dry conditions (80%-100% Hydrologic condition) smolt outmigration flows shall be provided at least 3 days per week in March, April, and May. If additional water is determined to be required, the City may further reduce smolt outmigration requirements at the Tait Street Diversion provided that: (a)

drought has been officially declared; and (b) this reduction in smolt outmigration opportunities will not reduce smolt migration more than one full day/week in the lower San Lorenzo River system or there is evidence from the San Lorenzo River or neighboring watersheds (i.e. Scott Creek) indicating that smolt migration is no longer occurring.

[4] April adult migration flows provided in hydrologic conditions 1-3.

4.4.2.2 Reservoir Operations

This section describes the overall approach to minimizing the effects of the City reservoir operations.

Chemical Algaecide Treatment of the Reservoir

Operation of Newell Reservoir has the potential to indirectly affect Covered Species habitat related to treatment of the reservoir with algaecide containing copper but is expected to have minimal effects. Monitoring of copper levels below the reservoir has shown that copper levels are in compliance with applicable limits of the State Water Resources Control Board Basin Plan. Reservoir releases are further diluted in the San Lorenzo River and by additional downstream tributaries, including the Zayante Creek and Branciforte Creek watersheds. The following measures are meant to avoid or minimize effects of this activity to negligible levels.

Measure WS-47: Avoid application of algaecide except when algae blooms occur. In the case where reservoir overflow cannot be prevented or is imminent, allow algae to bloom and do not apply copper-containing aquatic pesticides.

Measure WS-48: Minimize copper application through use of peroxide-based algaecides whenever possible and GPS-guided application.

Measure WS-49: Adhere to the Aquatic Pesticide Application Plan and algaecide label instructions.

Measure WS-50: Avoid release of treated surface water by application of algaecide at least 50 days before there is any potential for the Reservoir to spill (City of Santa Cruz Water Department 2005)

Measure WS-51: Lower the lake level prior to application of copper-containing aquatic pesticides if there is a risk of rain by drawing more water to the plant for treatment, releasing reservoir water from the deluge valve, and/or increasing release through the creek flow maintenance system.

Measure WS-52: Implement a monitoring program to assess the copper application, verify that application control goals are met, and to monitor copper discharges to Newell Creek through the fish water release.

Testing Deluge and Gate Valves

Testing of the deluge and gate valves on the dam can result in the discharge of approximately 100,000 gallons of moderate to low oxygen (1-6 ppm) at a range of 9-17˚C approximately) water to Newell Creek immediately below the dam. The following measures should reduce the potential for effects to negligible levels (below the threshold for take):

Measure WS-53: Do not release water warmer than 18 ˚C.

Measure WS-54: Release discharge into boulders/broken concrete below the dam to prevent scour of the streambed and provide aeration.

Measure WS-55: Monitor DO and turbidity levels just below the Newell Creek Dam road crossing to confirm aeration of released water and control of turbidity. Discontinue releases if adverse levels are observed.

Measure WS-56: Meter out releases so that changes in streamflow are minimized and mimic the natural rise and fall of a natural hydrograph. Record flows at the stream gaging station located several hundred feet downstream of the dam.

Measure WS-57: Conduct releases at times when lake coppering is not occurring, or otherwise ensure that releases do not have copper levels higher than that allowable by the Basin Plan.

Woody Debris Removal on Reservoir Face

The presence of Newell Creek Dam prevents the movement of woody debris to downstream reaches. Woody debris can be an important component of habitat for steelhead and coho. On average, there are 10 cubic yards of wood removed annually. Larger pieces are set aside for later use in instream restoration projects. Effects of this activity cannot be completely avoided but could be mitigated through projects that install large woody structures in downstream reaches, possibly in combination with gravel enhancement.

Measure WS-58: Continue the practice of reserving larger pieces of wood for use in restoration projects.

4.4.3 Water System Operations and Maintenance

This section describes the overall approach to minimizing the effects of the City’s operations and maintenance activities related to water systems operations and maintenance. There are general measures in place that apply to work around water bodies and avoid or minimize effects to Covered Species and their habitats. These measures include:

Measure WO-1: Conduct activities outside of the wetted channel whenever feasible by timing work to the low flow season or by utilizing equipment or methods that do not require access in the channel.

Measure WO-2: Conduct activities during the low flow season (June through October) whenever possible.

Measure WO-3: Minimize sediment input into the channel by installing erosion control devices and fencing as appropriate.

Measure WO-4: Store construction materials outside of the stream channel area and cover loose soils and materials while stored.

Measure WO-5: Minimize disturbance to banks and riparian vegetation. Proactively restore impacted riparian vegetation with native species.

Measure WO-6: Minimize removal of overstory/canopy trees that provide shade to the stream channel or banks through marking trees to not be removed.

Measure WO-7: Limit management of vegetation that is stabilizing the stream banks to trimming and pruning.

Measure WO-8: Remove non-native vegetation where accessible and where removal would have demonstrable habitat benefits.

If work within the wetted channel cannot be avoided, the following measures will be implemented.

Measure WO-9: Isolate the work area and bypass flowing water around the work site.

Measure WO-10: Relocate fish from areas to be dewatered to nearby suitable habitat (see Measures WO-24 through WO-32 for fish relocation measures).

Measure WO-11: Remove any foreign materials from the channel before re-watering.

Measure WO-12: Minimize potential for hazardous spill from heavy equipment by not storing equipment in the channel and equipping vehicles with spill kits.

Measure WO-13: Refuel vehicles a minimum of 50 feet outside the channel.

Measure WO-14: Develop staff training manual for working in waterways and protecting water quality. The manual will describe applicable conservation measures, agency and permitting authorities, biological issues, and habitat types and for conducting work in waterways and for protecting water quality. This manual will be distributed to field staff and via the City's intranet system. Annual field training will accompany the manual.

These general measures apply whenever work is performed near water. Avoidance and minimization measures for specific activities conducted under Water System Operation and Maintenance are described in the following sections.

4.4.3.1 Water Diversion Sediment Management

Laguna, Reggiardo and Majors Creek diversions on the North Coast are concrete impoundments that can collect sediment and debris during storm flows. The Reggiardo impoundment has filled with sediment and is only minimally functional (Chapter 3). The City diversions do not create sediment, but sediment may accumulate behind the dams during storm flows and if the diversion is not properly operated this sediment may be passed downstream in a concentrated plug. These sediment plugs may impair habitat for production of benthic macro-invertebrates as a food source for Covered Species, and impair habitat for spawning, egg incubation, and juvenile rearing. Implementation of the following measures will avoid effects to steelhead or coho habitat in the North Coast streams.

Measure WO-15: Until completion of rehabilitation projects provided in WO-17, operate diversions to pass the bedload and suspended sediment through the impoundment on stormflows by opening a slide gate in the dam face during the ascending hydrograph and then closing it again on the receding limb. At the Liddell Spring Diversion crack the valve to allow sediment to pass through without accumulating in the spring box and to allow transport of the peak of the hydrograph when necessary.

Measure WO-16: Remove any sediment that does collect behind the dams or in the Liddell Spring Box using hand tools, suction pumps, backhoes or vacuum equipment during the dry season (August – October) or in occasional emergency conditions in the winter time during low flow conditions. Remove sediment from site immediately or store it temporarily on site with appropriate sediment and turbidity containment.

Measure WO-17: Rehabilitate Laguna Creek diversion, Reggiardo Creek diversion, and Majors Creek diversion to allow flow and sediment to move naturally down the stream channel during high flows and avoid any potential for "pulsing" of sediment to downstream habitat (Chapter 3).

4.4.3.2   Fish Ladder and Screen Maintenance

The only City facility with a fish ladder is the Felton Diversion on the San Lorenzo River.[46] If the ladder becomes clogged with debris it can impair migration of Covered Species. There are fish screens at each of the diversions. Design screen face velocities can be altered by accumulation of debris on the screens, increasing the potential for impingement of smaller fish. Damage to the screens or seals can result in entrainment of susceptible life stages into the diversion. Although no issues with impingement or entrainment of fish have been observed at any of these facilities, inspection and maintenance measures will ensure such effects are avoided or minimized.

Measure WO-18: Inspect fish ladder 2-3 times per week or daily during storm flows and manually clean and remove debris as needed. Remove debris from site and dispose at approved waste disposal facility.

Measure WO-19: Inspect all fish screens daily and manually clean and remove debris from screens and debris racks as needed.

4.4.3.3   Pipeline Operations

Adequate operation of the water transmission lines requires system flushing and repairs and specialized operations, including pumping from clearwells to prevent sand accumulation and valve blow-offs to prevent breaks in the transmission lines.

<u>Conveyance Pipeline System Inspection and Repairs</u>

The City's two major raw water conveyance lines are the Newell Creek Conveyance Pipeline and the North Coast Conveyance Pipeline (Chapter 3). Discharges from leaks on these pipelines

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[46] Should the future rehabilitated Tait Street Diversion include a fish ladder, similar activities will also occur there.

may cause erosion and turbid runoff to surface waters when located adjacent to waterways. Pipeline routes are regularly inspected for leaks and pipeline rights of way are maintained to allow for inspection of the pipeline. Repairs are conducted under the oversight of environmental monitors, and include relevant avoidance and minimization measures as provided in Section 4.4 and standard City SOPs (Appendix 10: *Pipeline Repair and Flushing Standard Operating Procedures*).

The potential for effects to steelhead and coho from pipeline maintenance and repair is very low. Major pipeline leaks are an isolated and infrequent occurrence. Construction practices and BMPs to minimize and avoid sediment discharge to water courses, and contain sediment and spills are expected to result in negligible effects of this activity to steelhead or coho (Measures WO-1 through WO-14, Section 4.4.3).

Finished Water Pipeline System Flushing and Repairs

The finished water pipeline distribution and conveyance system includes approximately 300 miles of pipeline in the water distribution area (Chapter 3). The distribution line must be kept clean of bacteria and contaminants and requires testing for hydrant capacity as well as pipeline repairs. As described in Chapter 5, flushing at high velocities can erode soil and cause instability, uproot vegetation and cause drainage problems. Chlorine is toxic to nitrifying bacteria and other aquatic life, including the Covered Species. Spikes of ammonia and nitrite result in gill damage in fish, which can cause respiratory failure and suffocation.

Three SOPs (SOP nos. 7102-01, 7102-02 and 7105-01) describe the procedures to be followed when flushing any part or portion of the distribution system for the reduction of impacts of potential chlorine and sediment discharges. The SOPs provide details on dechlorination and flushing procedures as well as follow-up water quality testing for turbidity, chlorine residual, temperature, and pH. In addition, the Department’s coverage under the Statewide General NPDES Permit for planned and emergency Drinking Water System Discharges (order WQ 2014-0194) describes procedures for BMPs and monitoring to be followed when flushing and repairs result in discharges to waters of the United States. Dechlorination is accomplished by addition of sodium sulfite tablets or ascorbic acid solution to the discharge flow. For main flushing, hydrant testing, or main dewatering through a blow off, a dechlorinating diffuser assembly is typically used. Additionally, Vactor trucks or flushing directly to the sewer line are used to prevent discharges when feasible. See Appendix 10: *Pipeline Repair and Flushing Standard Operating Procedures* for SOP details. See Appendix 11: *Drinking Water Discharge General NPDES Permit*.

Other measures may include preventing riparian erosion and hydromodification by implementing flow dissipation, erosion control, and hydromodification-prevention measures; and minimizing sediment discharge, turbidity, and color impacts by implementing sediment, turbidity, erosion, and color control measures.

Measure WO-20: Follow Stormwater SOPs, including SOP 7102-01 Superchlorinated Potable Water Discharges, SOP 7102-02 Low-Chlorine Potable Water Discharges, and SOP 7105-01 Sediment and Turbidity Control During Open Channel Water Discharges.

Measure WO-21: Follow Sediment Control for Open Water Channel Discharges – Water Department SOP #8300-01, including procedures for controlling sediment during main or service break repair activities and any other activities that involve open channel discharges to the storm drain system or receiving waters. This includes use of vacuum truck to eliminate discharge; filtration with pea gravel bags before discharge to storm drain; and overland filtration.

Pumping Well Return to San Lorenzo River

As described in Chapter 5, there is virtually no effect from this activity on Covered Species and no avoidance or minimization measures are required.

North Coast Valve Blow Off to San Lorenzo River

When pressure in the North Coast Pipeline threatens to rupture the line, water is discharged to the San Lorenzo River at the Coast Pump Station at the Tait Street Diversion (Chapter 3). The approximate amount of discharge during this operation ranges from 5-10 cfs. The water is discharged over rip-rap to the San Lorenzo River downstream of the intake. Recently installed pressure relief valves minimize the potential for this occurrence. There is very little potential for effects from this activity on Covered Species and no avoidance or minimization measures are required.

4.4.3.4 Dewatering of Creeks for Maintenance and Repairs

The City performs various types of instream work including, repair and maintenance of diversion facilities, sediment management, fish ladder and fish screen maintenance and repair, pipeline operations and maintenance, flood control and stormwater maintenance, vegetation management, and aquatic habitat management. During the course of instream work for various purposes (Chapter 3) it is often necessary to dewater up to 200 feet and otherwise disturb portions of stream channels. In order to minimize effects of these activities on aquatic species, including

Covered Species, the City captures aquatic species in the project area and relocates them to suitable habitat outside the project area. The following measures will be implemented to minimize and avoid effects to Covered Species from these activities.

Measure WO-22: If work areas are to be de-watered, as many individuals of the Covered Species as possible will be captured and relocated prior to draining the site. The work area will be isolated with block nets and Covered Species will be captured, transported in buckets, and released in the most appropriate habitat (i.e., similar habitat conditions) immediately adjacent to the de-watered area. Methods will be determined based on the site conditions but may include electrofishing, dipnet, or seine. The number of individuals relocated will be estimated for each species prior to release. As the work site is de-watered, the remaining pools will be inspected for presence of Covered Species. Handling and holding time will be minimized to the maximum extent practicable.

Measure WO-23: Only NMFS-approved biologists will participate in activities associated with the capture, handling, and monitoring of Covered Species. The City will provide NMFS with the names and credentials of personnel proposed to conduct these activities for review and approval at least 15 days prior to the onset of the activities. No capture, handling, or monitoring activities will begin until NMFS notifies the City in writing that the biologist(s) is approved.

Measure WO-24: Prior to the onset of activities that result in disturbance of potential Covered Species habitat or individuals, a NMFS-approved biologist will conduct a training session for all construction personnel. At a minimum, the training will include: a description of the Covered Species and their' habitat; the importance of the species and their habitat; the general measures that are being implemented to conserve the species as they relate to the project; and the boundaries within which the project may be accomplished. Brochures, books, and briefings may be used in the training session.

Measure WO-25: A NMFS-approved biologist will monitor the work site until all removal of Covered Species, and habitat disturbance have been completed. After this time, the City will designate a person to monitor on-site compliance with all minimization measures. The approved biologist will ensure that this individual receives training in the identification of Covered Species and on the topics outlined above in Measure WO-26. The monitor and the approved biologist will have the authority to halt activities to avoid death or injury to individuals of the Covered Species. If work is stopped, the City will notify NMFS of the event within 48 hours.

Measure WO-26: If a work site is to be temporarily de-watered by pumping, intakes will be completely screened with wire mesh not larger than five millimeters (mm) to prevent Covered Species from entering the pump system. Water will be released or pumped downstream at an appropriate rate to maintain instream flows during construction. Upon completion of construction activities, any barriers to flow will be removed in a manner that would allow flow to resume with the least disturbance to the substrate.

Measure WO-27: If project activities could degrade water quality, the existing water quality parameters will be determined (e.g., temperature, DO, pH, and turbidity) prior to the onset of work. Water samples will be taken in a manner that minimizes disturbance, injury, or mortality of Covered Species. Results will be used to monitor water quality parameters during and after maintenance and sediment removal activities.

Measure WO-28: Work activities will be conducted between July 1 and October 31 to the maximum extent practicable. Should the City need to conduct activities outside this period, it will notify NMFS.

Measure WO-29: If the substrate of the natural stream channel is altered during work activities, it will be graded or otherwise restored to approximate natural conditions after the work is completed.

Measure WO-30: The number of access routes, number and size of staging areas, and the total area of the activity will be limited to the minimum necessary to achieve the project goal. Routes and boundaries will be clearly demarcated, and these areas will be outside of sensitive riparian and wetland areas.

Measure WO-31: To mitigate for the small residual effects of this activity, the City will incorporate habitat improvement features with any scheduled (non-emergency) instream repair work whenever feasible. This could be relatively efficient since there will likely be heavy equipment on site for the repair work and habitat features (e.g. LWD, boulder placement, or additional riparian plantings beyond what is needed for bank stabilization) could be efficiently added. If installation of habitat features at the work site is judged to be impractical or not particularly beneficial, an offsite installation of similar dimensions will be installed elsewhere to achieve a 1:1 mitigation ratio.

4.4.4 Municipal Facility Operations and Maintenance

Municipal facility operations and maintenance activities include operation, rehabilitation, replacement, repair and maintenance of existing infrastructure and related facilities, flood control maintenance, stormwater maintenance, and vegetation management. This section describes the overall approach to minimizing the effects of the City's operations and maintenance activities related to municipal facilities.

4.4.4.1 Flood Control Maintenance

This section describes the overall approach to minimizing the effects of the City's flood control maintenance activities which are conducted to prevent flooding of city waterways and damage to public and private property. These activities can occur anywhere on City facilities and properties in the HCP Plan Area but are largely centered on the San Lorenzo River and Branciforte Creek FCC.

The major effect of the FCCs has been through extreme habitat alteration as a result of its construction. Given the scale of alteration through construction, maintenance has relatively contained effects. The City has worked with the Corps of Engineers to incorporate growth of limited riparian vegetation into the maintenance parameters for the FCC. Flood control maintenance includes debris/obstruction removal, sediment management/removal, and vegetation management (Chapter 3). The San Lorenzo River FCC has habitat components that support salmonid adult migration, smolt migration, and rearing. Sediment and vegetation management has the potential to alter this habitat to the detriment of salmonids. The Branciforte Creek FCC has structural components that likely impede adult salmonid migration and diminish suitability for smolt migration and juvenile rearing (bare concrete rectangular channel with minimal central low-flow channel). Accumulation of sediment in the Branciforte FCC can lead to development of minimal habitat features including riffle-pool sequences and colonization of cover producing vegetation. When sediment bars and vegetation are present, fish species including juvenile steelhead and lamprey, can occupy the habitat in low numbers and there is potential for improved conditions for migration (HES 2003b).

Debris/Obstruction Removal

Debris/obstruction removal has the potential to damage aquatic habitat and even cause direct injury or mortality to Covered Species. Removal of logs, root wads, and other large woody material removes potential habitat elements and can result in simplification of the habitat and loss of material that would have provided valuable cover. Instream work with heavy equipment may directly impact Covered Species if they are present in the area and contacted by machinery or moving objects.

The following measures, in addition to WO-1 through WO-14, will avoid and minimize effects of this activity.

Measure MF-1: Only remove material that creates a hazard to life, property, infrastructure, or public safety.

Measure MF-2: Involve a biologist with knowledge of Covered Species habitat needs as part of the team that evaluates need to remove materials and methods to be used. Have work overseen by environmental monitors and implement standard measures for instream work (See preceding).

Measure MF-3: Whenever possible leave natural habitat-forming material in the stream by moving it downstream of structures to be protected or cutting larger material into smaller segments that may float downstream in larger flows, as long as these segments retain habitat forming characteristics.

Measure MF-4: Allow retention of up to 3-foot square root wads in the channel every 500 feet for habitat value, provided there are no undesirable changes in channel hydraulics and provided such root wads do not show signs of developing into larger log jam structures in the future.

Flood Control Sediment Management/Removal

Accumulation of sediment in City waterways can provide habitat for benthic invertebrates and certain vertebrate species such as larval Pacific lamprey. Accumulated sediment also forms a matrix for establishment of rooted aquatic, emergent aquatic, and riparian vegetation including shrubs and trees. Together these features have the potential to create habitat suitable for Covered Species. Although this habitat is somewhat degraded and transient, its removal has the potential to effect Covered Species that are using it, both through removal of habitat and potential direct harm resulting from use of equipment for removal of vegetation and sediment.

Sediment removal in the FCCs is conducted in habitat that is degraded by construction of the channel. Few Covered Species are present in much of the area where sediment is to be removed. Sediment removal in the Branciforte FCC occurs annually, primarily in the lower part of the channel. Sediment accumulation in this reach forms limited amounts of low quality potential rearing habitat in a short section of the channel (HES 2014c). The potential habitat in the FCC represents an insignificant component of the total rearing habitat in the watershed. The 2004 Biological Opinion for sediment removal from the project concluded that the steelhead rearing capacity of Branciforte Creek was reduced with construction of the concrete FCC and remains reduced with ongoing channel maintenance activities (NMFS 2004). Branciforte Creek upstream of the concrete FCC provides 10.5 miles of salmonid spawning and rearing habitat and another 8 miles in three major tributaries. Salmonid spawning in Brancifote Creek occurs upstream of the FCC as does higher quality summer rearing habitat (NMFS 2004). The value of any habitat that forms in the FCC via sediment accumulation and establishment of vegetation is limited and much larger areas of higher value habitat exist in the Creek and San Lorenzo River watershed (NMFS 2004). Impacts to Covered Species potentially rearing in areas where sediment removal will occur will be minimized by capturing and relocating them prior to sediment removal activities (Section 4.4.3.1).

The FCC reach of Branciforte Creek also provides migration habitat for access to the rest of the watershed. Removal of sediment and vegetation has the potential to change migration conditions but only in the lower part of the FCC where it occurs. If the presence of sediment and vegetation improves conditions for migration in the lower part of the FCC migration would still be limited by conditions in the remaining, upper part of the FCC. In the Biological Opinion for FCC Maintenance, NMFS did not expect that the quality of adult steelhead migration habitat would be reduced as a result of sediment and vegetation removal activities (NMFS 2004). Presumably this finding would apply to coho as well.

The following measures are consistent with the City’s ongoing management practices implemented in coordination with the Army Corps of Engineers. Implementation of these measures, in addition to WO-1 through WO-14, will avoid and minimize the effects of this activity.

Measure MF-5: Conduct sediment removal only as necessary to maintain and/or restore capacity of stormwater conveyance facilities or to prevent flood events; define sediment removal areas in the San Lorenzo River FCC by cross section and HEC-6 analysis.

Measure MF-6: Conduct a pre-project survey to define important salmonid habitat areas, including riffles, pools, and runs, and avoid sediment removal in these areas.

Measure MF-7: Conduct annual surveys to identify vegetation characteristics and sediment aggradation within the San Lorenzo River FCC between Highway 1 and Soquel Avenue, and in the Branciforte Creek FCC.

Measure MF-8: In the San Lorenzo River FCC maintain a 5-foot vegetation no-work buffer along both sides of the wetted channel where sediment removal activities will not occur.

Measure MF-9: In the San Lorenzo River FCC disk bars annually during dry season to loosen root materials and promote scour. Encourage existing cross-channel scour areas through disking and manipulation of discarded root wads/vegetation material.

Measure MF-10: Do not conduct sediment removal in San Lorenzo River FCC downstream of Laurel Street.

Vegetation Management

Under current management practices vegetation management focuses on trimming or removing riparian vegetation that may impede storm flows, result in bank erosion, or result in damage to property. Growth of riparian vegetation in the San Lorenzo River FCC is allowed as long as the Army Corps of Engineers requirements for channel capacity and roughness criteria are met. This has resulted in riparian vegetation, including overhanging willows and other shrubs and small trees to become established and provide rearing habitat for steelhead. Removal of aquatic and riparian vegetation has the potential to diminish habitat value for covered species and to directly harm Covered Species if work is conducted instream.

Measure MF-11: Do not remove mature riparian trees except in the San Lorenzo River FCC and Branciforte Creek FCC; riparian shrubs may be trimmed from ground level up to 6-8 feet in height. Remove cuttings from the work area and recycle as green waste at the landfill or chip and leave in place.

Measure MF-12: Avoid vegetation management in the wetted channel to the maximum extent practicable. For work in the wetted channel follow measures for in-channel work (WO-9 through WO-14).

Measure MF-13: Conduct vegetation management late in the dry season, preferably August.

Measure MF-14: Selectively remove riparian vegetation that could possibly undermine the stability of the levees or exceeds accepted Army Corps of Engineers' "Manning's n roughness coefficient" for the FCC. Retain a minimum 5-foot vegetated buffer on either side of the wetted channel.

Measure MF-15: In the reach from Highway 1 to Water St., allow 10-foot-wide strip of willow and alder along toe of levee. Willows allowed to grow to 3 inches dbh; alders allowed to grow to 6 inches dbh. Trim lower limbs of the alder trees to reduce flood impacts. Thin willows to favor providing overhanging cover to the low flow channel. Maintain a 5-foot buffer along wetted edges of channel, but thin groves and limb-up trees. Remove any trees in 5-foot buffer area that are greater than 6 inches dbh.

Measure MF-16: In the reach from Water St. to Laurel St. maintain a 10-foot-wide strip of woody riparian vegetation and tules and cattails on the west bank. Maintain east bank to keep trees overhanging water. Trees or branches that fall in the water may be left, cut into smaller pieces, or removed entirely if they cause an immediate safety hazard. Maintain sandbars to allow volunteer groves to establish but remove all trees greater than 6 inches dbh.

Measure MF-17: In the reach downstream of Laurel St. maintain a 5-foot-wide strip of willow, cattail and tule at the levee toe. Willows will be maintained with stem diameter of no greater than 0.5 inches and be limbed-up and periodically thinned to create defined groves.

4.4.4.2 Stormwater Maintenance

The City's Public Works Department maintains a system of drains, conduits, and pumps for the purpose of draining storm flows. The system can be a source of pollutants, increases peak storm flows in receiving waters, and minimizes percolation of rainfall into the ground.

City stormwater runoff mainly influences steelhead habitat in the San Lorenzo River Lagoon, and mainly during the winter months. During the winter months, steelhead are transient within the lagoon, with adults moving upstream from December through April and smolts moving downstream, primarily in April and May.

The City developed and is implementing a Stormwater Management Plan (SWMP) in compliance with the NPDES Phase II General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4s) and for general reduction of pollutants in urban runoff. The City has also developed implementation plans for TMDLs for pathogens (Fecal Indicator Bacteria, (FIBs)) and sediment in the San Lorenzo River Watershed. The SWMP[47] includes the following measures that avoid and minimize effects of stormwater discharges.

Measure MF-18: Continue to implement Municipal Operations/Pollution Prevention and Good Housekeeping Program to prevent pollutants generated by municipal operations and activities from entering the storm drain system by implementing measures to prevent or reduce pollutant runoff from municipal operations.

Measure MF-19: Continue Illicit Discharge Detection and Elimination Program is to detect and eliminate illicit connections and illegal discharges to the storm drain system from a variety of

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[47] http://www.cityofsantacruz.com/government/city-departments/public-works/stormwater/storm-water-management-plan

sources, including industrial facilities, commercial establishments, residential areas, and construction sites.

Measure MF-20: Continue Public Education Program to increase public awareness on urban runoff pollution issues, to educate the community about specific sources of pollutants and what people can do to reduce them, to foster participation through community-based projects or volunteer activities focused on pollution prevention, and to decrease the amount of illegal dumping and polluted urban runoff that is discharged into the storm drain system.

Measure MF-21: Continue "Construction Site Stormwater Runoff Control Program" to protect the City's storm drain system and receiving waters from pollutants that may be discharged as a result of construction activities, including clearing, grading, excavation, landscaping, building, and remodeling of existing buildings. Minimize land disturbance at all permitted construction sites, protect water quality from pollutants generated by construction activities, and require measures to be implemented at all permitted construction sites.

Measure MF-22: Continue Post-Construction Stormwater Management to ensure that new developments and remodeled sites are designed and constructed in a manner that minimizes the alteration of natural watercourses and drainage patterns, as well as alleviating the impact of new developments or remodeling projects on a site's and surrounding natural hydrology.

Measure MF-23: Continue the Industrial Facilities Program to reduce urban runoff pollution generated by industrial facility operations and activities and to ensure that industrial facilities comply with the City's Stormwater Ordinance, mandatory measures, and Industrial Waste Discharge Permit requirements (as applicable).

Measure MF-24: Continue the Program Effectiveness Assessment and Improvement Plan to track annual and long-term effectiveness of the Stormwater Program at protecting water quality. Use results of the assessment to adaptively manage Stormwater Program by providing supporting documentation for proposed modifications.

Measure MF-25: Reduce pollutant loading from multiple City sources to the maximum extent practicable in the San Lorenzo River, San Lorenzo River Lagoon, Branciforte Creek and Carbonera Creek consistent with Implementation Plans for TMDLs for sediments and pathogens.[48]

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[48] https://www.waterboards.ca.gov/rwqcb3/water_issues/programs/tmdl/docs/san_lorenzo/sediment/slr_sed_tmdl_proj_rpt.pdf

Storm Drain Inspection and Cleaning

A variety of urban pollutants can flow to and accumulate in the storm drain system. These pollutants could ultimately be washed into receiving waters occupied by Covered Species. In response to this, the City implements an annual storm drain inspection and cleaning program, “Team Clean,” to remove pollutants prior to them being transported by stormwaters (Chapter 3). The following elements of this program avoid and minimize effects of the storm drain system on Covered Species to the maximum extent practicable.

Measure MF-26: Use City developed GIS layer for storm drains to create preventative maintenance schedules for catch basins and inlets and maintenance tracking software system, CMMS Maintenance Connection, to help with scheduling and tracking inspections, cleanings, and upgrades of stormwater facilities.

Measure MF-27: Conduct CCTV camera inspections of storm drain lines as needed each year to help evaluate the condition of storm drain lines and identify repair needs.

Measure MF-28: Use Combination Sewer Cleaning unit[49] or similar appropriate tool and hand cleaning to clean storm drains. Plug lines at both ends and employ combination unit, using reclaimed water, to “hydro-jet” the line, and then vacuum the line to remove sediment and other material. Dispose of resulting sediment and other material at the Resource Recovery Facility (landfill) after dewatering at the Wastewater Treatment Plant.

Measure MF-29: Inspect sediment basins and clean known problem basins (basins that collect large amounts of sediment and trash) at least monthly or more frequently during wet season. Dispose of collected debris at the Resource Recovery Facility.

Measure MF-30: Inspect and clean intensive-use basins semi-annually using a combination unit. Clean monthly during September and October. Dispose of collected debris at the Resource Recovery Facility.

Measure MF-31: Inspect and clean commercial basins annually.

Measure MF-32: Inspect residential basins on an eight-year cycle and clean, as necessary.

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https://www.waterboards.ca.gov/rwqcb3/board_decisions/adopted_orders/2008/2008_0001_slr_path_tmdl_att_2_proj_rept_21mar08.pdf

[49] https://cdn2.hubspot.net/hubfs/6860826/FED12-Impact%20Brochure_1.20_WEB.pdf

Measure MF-33: Inspect pump stations along San Lorenzo River weekly and clean at least bi-annually and after large storm events.

Measure MF-34: Inspect large diameter stormwater pipelines (including inlets, culverts, bar racks, screens, and vaults) annually, and clean at least on a five-year cycle.

Measure MF-35: Inspect small diameter stormwater pipelines (including inlets, culverts, and vaults) on a two-year cycle, and clean as needed or on a fifteen-year cycle.

Structural Retrofits and Storm Drain Inlets and Basins

The City focuses on two types of structural controls to improve water quality associated with the storm drain system: dry-weather diversion systems to divert flow to the sanitary sewer for treatment at the Wastewater Treatment Facility and sewer replacement projects in the Beach Flats area in order to reduce inflow/infiltration, including installation of Tideflex valves on multiple storm drain outlets along the San Lorenzo River. The valves open to release storm drain water through gravity flow into the river and close to prevent high river levels from back-flowing into the storm drain lines (Chapter 3).

The overall effect of this activity is beneficial in that it improves water quality conditions, particularly in the Lower San Lorenzo River and Lagoon, during the summer when rearing steelhead may be present. There may be very limited potential for this activity to temporarily adversely affect Covered Species during project construction. These effects can be avoided and minimized through implementation of Measures WO-1 through WO-14 (Section 4.4.3).

Sanitary Landfill Stormwater Management

As described in Chapter 5, operation of the Santa Cruz Landfill has no effect on Covered Species and no avoidance or minimization measures are required.

4.4.4.3 Emergency Operations and Response

Emergency operations are developed in response to specific emergency incidents such as storms, floods, fire, earthquakes, and hazardous spills. Response may include the use of heavy equipment near waterways and removal of debris and structures in waterways, placement of bank revetment, excavation of sediment which occludes valves and pipelines, patching and shoring of pipelines and related actions to preserve the functions of City infrastructure. Measures discussed under Water System Operations and Management and Municipal Facilities Operations and Management for these activities are applicable to emergency situations as well.

4.4.4.4 General Vegetation Management Within Riparian Corridors

The vast majority of vegetation management activities occur on land with only limited proximity to stream courses supporting steelhead or coho. For vegetation management in riparian areas refer to Measures WO-1 through WO-8. In addition, the following measures avoid and minimize the effects of this activity on Covered Species to the maximum extent practicable.

Measure MF-36: Trim vegetation using hand tools and maintain canopy, downed trees, and snags to the extent possible. Leave downed wood on the ground and lop only as required for fire safety or to facilitate moving downed wood off of roads and trails.

Measure MF-37: Remove non-native invasive plants through hand trimming and limited herbicide application according to the City's Integrated Pest Management Program.

4.4.5 Land Management

This section describes the overall approach to minimizing the effects of the City's land management activities.

4.4.5.1 Management of Loch Lomond Recreation Area and Watershed Lands

Activities associated with facility maintenance and management include facility repair, trail maintenance and management, trail construction, and road maintenance and decommissioning. These activities occur on all the open space properties owned by the City and in the Newell Creek and Zayante Creek watershed properties.

<u>Trail Maintenance and Repair</u>

City maintained trails can result in generation of sediments that find their way into watercourses inhabited by Covered Species. The City practices trail maintenance and management on open space and watershed lands to keep trails in good physical conditions and avoid mobilization of sediments. The following measures ensure that effects of this activity are fully avoided.

Measure LM-1: Restrict vehicle access during wet weather (except for emergency access); require use of ATVs for winter access.

Measure LM-2: Install drainage improvements such as culverts, dips, and bars; and realign trail segments to avoid sensitive habitats and steep slopes.

Measure LM-3: Remediate existing erosion areas on an annual basis.

Measure LM-4: Conduct ranger patrols to ensure appropriate use of trails and adherence to closures or restrictions. Remove unauthorized trails as resources permit.

4.4.5.2 Road Maintenance and Decommissioning

The City maintains roads on the watershed lands it manages. These roads potentially contribute increased sediment loads to water courses that may support Covered Species through erosion from road surfaces, slope failures, and culvert malfunction or failure. The following measures will be implemented to avoid and minimize effects of this activity on Covered Species.

Measure LM-5: Conduct all road work with the support of a Registered Professional Forester and Certified Erosion Control Specialist, with engineers also being involved on more difficult road projects (City of Santa Cruz 2010).

Measure LM-6: Use culverts: (1) to route drainages through the road prism; (2) where in-sloping has to be maintained to pick up bank seepage; or (3) to control drainage away from a landslide or road fill failure. Maintain culverts and trash racks; maintain proper energy dissipation at outlets; clear bank slough; conduct bank stabilization; and hand dig rolling dips and/or water bars as necessary to maintain appropriate drainage. Conduct culvert replacement or upgrades in July – September with hand tools and heavy equipment.

Measure LM-7: Maintain unpaved roads as out-sloped dirt roads, with rolling dips and/or water bars to manage drainage. Manage unpaved roads as “restricted use” roads that are not used in winter under saturated conditions. These roads may be rocked to reduce road surface sediment production, to improve access for patrols or emergencies, and to extend the season that the roads can be traveled.

Measure LM-8: Reshape roads periodically as needed to maintain out-slope drainage and as appropriate for the road and topography. Complete reshaping work within the existing road width and cut fill area for most roads to avoid additional disturbance to adjacent areas. Apply rock, straw, and seed to bare soil areas, as necessary.

Measure LM-9: Decommission roads that are not necessary for patrolling the properties for security and trespass concerns (off-road vehicles, poaching, camping, etc.); fire access, resource management and habitat restoration; and maintenance of drainage infrastructure. To the extent practicable, decommission roads that are significant sediment sources and that cannot be treated by maintenance activities (Chapter 3).

Measure LM-10: To the extent practicable, roads no longer required for Covered Activities in the Newell Creek and Zayante Creek watershed lands will be decommissioned. For roads traversing relatively mild slopes with few drainage structures (culverts), complete more severe out-slope or slope as close to natural grade as possible without generating excessive levels of disturbance. Construct frequent, large water bars where water may still concentrate on the road. For roads in steeper topography, remove all fill from the down slope portion of the road and place this material on top of the roadbed cut surface (keyway) and compact against the existing cut bank. Construct a severe out-slope to bring the contour to as close to natural grade as possible. Restrict the area of disturbance associated with road decommissioning to the 14-16 foot width of the roadbed, plus an additional 15-20 feet for re-contouring of more benign roads, and 20-30 feet for the more difficult ones.

Measure LM-11: Install erosion control as necessary, including straw wattles, native duff, straw, jute netting, etc.

Measure LM-12: During road decommissioning, remove culverts by excavating the culvert fill with an excavator or backhoe, down to native grade, and removing the culvert. Restrict the area of disturbance associated with culvert removal to the 14-16 foot wide roadbed, plus the area to the outer edge of the fill (10-20 feet). Conduct additional work as needed for grade control and energy dissipation above and below the culvert removal site. Use gabion-sized rock to small rip-rap, or placement of large wood in the channel, as needed for channel stabilization upstream and/or downstream of the removed culvert. Restrict majority of channel adjustments from culvert removal to within 30-50 feet of the existing crossing.

Measure LM-13: Install erosion control measures for surface stabilization following culvert removal (straw, seed, straw rolls, blankets, etc.), and replant the disturbed area with native species, particularly conifer and riparian species.

Measure LM-14: Complete road decommissioning during June – September; select road segments that can be decommissioned, stabilized for erosion, and replanted with native species within one season. Conduct follow-up erosion control and further planting/care until the area is stabilized and growing.

4.4.5.3 Habitat Management

Habitat management includes resource management activities to improve, preserve and maintain existing sensitive habitats and species on City properties. Activities include habitat management and restoration, and public education.

Aquatic Habitat Management and Restoration

Aquatic habitat management protects and enhances habitat for Covered Species by adding or protecting fisheries habitat features, stabilizing stream bank erosion problems, and removing fish passage barriers. This results in a long-term beneficial effect on Covered Species. Short-term effects related to project construction will be avoided and minimized through implementation of WO-1 through WO-14 and the following measures.

Measure LM-15: Obtain appropriate state and federal permits prior to doing the work.

Measure LM-16: Complete projects in accordance with methods detailed in the California Salmonid Stream Habitat Restoration Manual (Flossi et al. 1998).

Measure LM-17: Complete work during the summer/ fall period (and before October 15), when streamflows are lower and work conditions are dry to minimize soil disturbance and mobilization, and the critical spawning and smolting periods are over.

Measure LM-18: Retain services of geomorphologists and aquatic biologists as necessary to consult on projects for design and implementation. Conduct ongoing physical profiling and biological surveys of project sites post-implementation to demonstrate effectiveness and provide feedback for future projects.

Monitoring

Monitoring activities involve access to sensitive instream and riparian habitat and capture and handling of protected species. The following measures are intended to avoid and minimize potential effects on steelhead, coho, and their habitat from monitoring activities.

Measure LM-19: Perform all monitoring activities under the guidance and supervision of the HCP Administrator or Conservation Program Manager in compliance with a Monitoring Manual prepared by the Conservation Program Manager. All individuals performing monitoring will have qualifying knowledge and experience and will be trained in implementation of the Monitoring Manual.

Measure LM-20: The monitoring program will be conducted in coordination with NMFS and CDFW through regular meetings (one to two per year) of an HCP Technical Advisory Committee.

Measure LM-21: Monitoring will be conducted under applicable Section 10, Scientific Collector's Permit, or other required authorizations. Standard practices for minimizing effects to protected species will be implemented.

4.5 Non-flow Conservation Fund

The application of avoidance and minimization measures will eliminate the effects of many of the Covered Activities on Covered Species. Some residual effects are unavoidable, however, including diversion-related effects at most diversions, effects of sediment and vegetation management in the FCCs, and repairs conducted instream that involve dewatering. These effects are summarized in Table 5-1 and described in Chapter 5. To ensure that effects remaining after the implementation of avoidance and minimization measures are fully mitigated, the City will implement a compensatory mitigation program to fund enhancement and restoration of Covered Species habitat. This section describes the approach to compensate for the residual effects of Covered Activities through the funding of non-flow habitat improvement projects. Mitigation will focus on actions that improve salmonid habitat in the North Coast and San Lorenzo watersheds.

The mitigation program is designed to address key limiting factors in watersheds where Covered Activities take place. The mitigation program will prioritize measures that address the life-stage and/or location directly affected by a specific activity. In some cases, however, direct on-site conservation actions may be impracticable or of limited benefit to the species. As such, conservation actions funded may include areas outside the Plan Area or be focused on other life-stages than those directly affected by Covered Activities.

4.5.1 Program Need and Goals

4.5.1.1 Program Need

Adoption of bypass flows under the HCP minimizes and avoids many of the existing sources of potential incidental take related to City activities. Nevertheless, some residual effects to Covered Species remain after implementation of bypass flows. The NFCF will provide funding for restoration and enhancement projects that will fully mitigate for the effects of Covered Activities.

4.5.1.2 Program Goals

The goal of the NFCF is to mitigate for residual effects of Covered Activities after implementation of BMPs and avoidance and minimization measures previously outlined in the Plan. Because most other Covered Activities do not have residual effects on Covered Species, once BMPs and avoidance and minimization measures are implemented, the NFCF analysis focuses primarily on water operations. The NFCF program has been designed to:

- engender collaboration between the City and NMFS to address new conservation issues and opportunities as they arise – maximizing the impact of funds from the NFCF;
- enable the City to work with NMFS to identify and implement projects that directly address residual effects to Covered Species, and also provide benefits to species habitat more generally and result in more resilient watersheds.
- create a program that balances administrative oversight and procedures for accountability with flexibility so that funding can be directed to projects that will provide the greatest conservation benefit.

4.5.2 Program Oversight and Decision-making

While implementation of the NFCF will require collaboration between the City and the agencies, the City will be responsible for implementing the program. The NFCF will be managed by the HCP Administrator.

The City will work with NMFS, CDFW, and an array of local partners (including private landowners) to develop a working list of potential NFCF projects. The City will propose projects from this list for approval by NMFS and CDFW. The City, NMFS, and CDFW will form a TAC to collaboratively develop the working NFCF project list, to review project concepts, and to provide design-level review of selected projects at key milestones (e.g. conceptual designs, 60% designs, etc.) during the planning process. Suggested projects can come from the agencies and others, including through a call for proposals. After review of potential project opportunities, the City will propose a project or suite of projects to NMFS and CDFW members of the TAC for approval. Projects that cannot garner support from both agencies will not be funded.

The TAC will use the following metrics to assess a given project for funding[50]:

- Does the project have the potential to benefit coho recovery as well as steelhead recovery?
- Does the project address a known residual impact resulting from implementation of the HCP?
- Does the project address a known limiting factor (as articulated in the Coho Recovery Plan or Steelhead Recovery Plan) for the covered species?
- Does the project enhance watershed conditions that lead to ecological resilience and healthy aquatic environments?
- Does the project have landowner support and stakeholder support necessary to ensure implementation?
- Are there any known constraints (stakeholders, technical, etc.) that are likely to significantly impede the ability of this project to be completed?
- Do the costs, in terms of financial commitment from the NFCF, and benefits to covered species compare favorably to other potential project opportunities?
- Is the estimated timeline for design, permit and construction within a 1-3 year window based on expected complexity of the project?

Potential projects will be evaluated over a planning cycle of 5 years. The 5-year project list can be revisited, as needed, during the planning cycle to address changed conditions or new opportunities. The number of projects selected for funding through the NFCF will vary for each 5-year planning cycle based on the size and complexity of projects. It is expected that most projects funded through the NFCF will require a 1-3 year project timeline from initial planning to construction.

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[50] Projects may include actions that remediate adverse effects to habitat caused by third-party violations of natural resource laws. Recovery hatchery support will be prioritized as appropriate and in consultation with the TAC. Timing of projects is contingent upon TAC priorities and financial projections described in Chapter 7.

4.5.3 Quantifying and Linking Impacts and Benefits

Ideally, impacts can be translated into a transparent, meaningful, and accurate common spatial metric such as acres, linear feet, etc. to enable translation into adequate mitigation. Creating this common variable for this process is particularly complex in light of the fact that the residual impacts identified through the Plan (such as those resulting from ongoing water diversion) utilizes comparative metrics or metrics of "change" (e.g., relative passability) versus specific spatial metrics. While the comparative metric approach makes sense for understanding the relative effects of the City's water diversions and operations, it does not enable simple translation to an absolute quantity of residual impact on physical habitat features. Moreover, the temporal nature of the impacts (impacts appearing only in certain water years) and biological scope of the impacts (impacts affecting only a specific life history stage) further complicate the calculus of developing an absolute (versus relative) spatial metric. Without a clear precedent in the literature or template for translating these impacts into a common spatial metric, the "Ecological Portfolio Method" was developed to translate residual impacts into a hybrid quantitative-qualitative mitigation metric (ecological portfolio) and then into a purely quantitative mitigation metric (dollars).

One of the most critical tasks for development of the NFCF has been creating a clear and direct link between the potential project types that could be funded and the specific residual impacts identified through the HCP. Table 4-9 displays this linkage by providing both a summary of the modeled residual impacts and a linked ecological portfolio of potential NFCF projects that would directly off-set these impacts. It is important to note that while the residual impacts are generally limited to a specific life history stage and/or water year type, many of the potential projects that would be implemented through the NFCF provide benefits across life history and water year types. An example of this might be placement of LWD structures to offset impacts to rearing in dry years. While these structures will provide deeper pools and pool tail-outs, which will increase summer rearing opportunities, if designed correctly they can also provide high flow refuge during wet winters and improve spawning opportunities through better substrate sorting.

Table 4-9 represents a conceptual approach for identifying the appropriate level of non-flow mitigation. The Ecological Portfolio concepts identified in this table for the purpose of estimating the financial size of the NFCF may or may not become the actual projects funded under the Plan. The actual projects selected for funding will be determined by the TAC based on restoration opportunities and priorities during Plan implementation. In Chapter 7, Table 7-3 sets out the schedule and cost allocation of the $8 million to fund twenty-two proposed projects over the thirty-year term of the Plan.

Table 4-9: NFCF Linkage between Residual Impacts and Ecological Portfolios[51]

	Residual Effect after Avoidance and Minimization			**Possible Ecological Portfolios to Mitigate Residual Impacts**		
Reach	***Steelhead***	***Coho[3]***	***Areal Extent***	***Action***	***Unit***	***Estimated Cost***
Laguna Anadromous	Small decrease in habitat suitability index (WUA) for spawning in normal (6% reduction) and wet (6% reduction) years	NA	1.4 mile anadromous reach with estimated 180 ft^2 of spawning gravel (2 square feet per 100 feet of stream) (ENTRIX, Inc. 2004)	Expand lower floodplain by 0.5 acres and complete Riparian corridor restoration along ~1.8 acres of SP property	2.3	$ 555,036
				Remove defunct bridge, abutments, and restore slope on Coast Rd (cost equivalent to small dam removal)	1	$ 151,650
	Moderate reduction in the habitat suitability index (WUA) for rearing by 16% in wet years and 6% in normal years	NA	1.4 mile anadromous reach	Install 14 anchored LWD structures in low 3/4 miles (~ every 200 ft)	14	$ 257,497
Liddell Anadromous	Decrease in number of days with suitable conditions for adult migration in normal (9% reduction to 86 days), dry (42% reduction to 23 days) and critical dry years (31% reduction to 9 days)	NA	1.2 mile anadromous reach	San Vicente Creek as a proxy for Liddell and Majors[1]		

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[51] Residual effects due to reduced wetted habitat resulting from water diversion at stream cross sections is translated from left to right in the table above more broadly into areal extent of habitat impacts in the respective stream and then into compensatory actions in the ecological portfolio. Unit refers to the number of project elements (i.e. one bridge, 2.3 acres, etc.). Costs estimated from comparable projects that have been recently planned or completed and include permitting/administrative costs.

	Decrease in WUA for spawning in normal (10% reduction), dry (31% reduction) and critical dry years (38% reduction)	NA	1.2 mile anadromous reach with estimated 716 square feet of spawning gravel (11 square feet per 100 feet of stream)			
	Decrease in WUA for rearing in wet (20% reduction), normal (23% reduction), dry (40% reduction) and critical dry years (44% reduction)	NA	1.2 mile anadromous reach	Cost share with County of Santa Cruz Sanitation District and others in the effort to develop a new, more sustainable water source for Davenport, which would improve instream flows for Covered Species.	lump sum	$ 500,000
	Decrease in number of days with suitable conditions for smolt migration in normal (6% reduction to 141 days), dry (35% reduction to 99 days) and critical dry years (57% reduction to 61 days)	NA	1.2 mile anadromous reach	Remove or modify 2 Mill Creek dams for fish passage and develop a new back-up intake for Davenport that enables fish passage to ~0.5 mile of stream and add 10 unanchored LWD structure in Mill Cr to improve rearing and spawning.	2 & 10	$ 587,883
Majors Anadromous	Decrease in WUA for spawning in normal (5% reduction), dry (23% reduction) and critical dry years (17% reduction)	NA	0.7 mile anadromous reach with estimated 49 square feet of spawning gravel (1.3 square feet per 100 feet of stream)	Restore downstream floodplain/backwater, remove historic spoils, and reconnect to mainstem (~1 acre) to improve rearing conditions for both species.	1	$ 895,695
	Decrease in WUA for rearing in all year types (20% to 24% reduction)	NA	0.7 mile anadromous reach	Cost-Share continue Cape Ivy and Clematis eradication efforts for 5 years to reduce overall potential impacts to riparian corridor, shade, and future LWD recruitment.	lump sum	$ 250,000

	Decrease in number of days with suitable conditions for smolt migration by 3 days in dry years (12% reduction) and 1 day in critical dry years (11% reduction)	NA	0.7 mile anadromous reach			
	Residual Effect after Avoidance and Minimization			**Possible Ecological Portfolios to Mitigate Residual Impacts[2]**		
Reach	*Steelhead*	*Coho[3]*	*Areal Extent*	*Action*	*Unit*	*Estimated Cost*
San Lorenzo below the Tait Street Diversion[4]	Decrease in WUA for rearing in wet (9% reduction), normal (15% reduction), dry (16% reduction) and critical dry years (15% reduction)	NA	Up to 1.4 miles of riverine habitat, including 0.9 miles of FCC, depending on lagoon stage, and up to 1.5 miles of lagoon habitat	Create shade, scour and refugia for rearing in lagoon/tidal areas downstream of Laurel Street through installation of 10 dynamic anchored LWD clusters	10	$ 390,237
	Decrease in number of days with suitable conditions for adult migration in dry (8% reduction to 133 days) and critical dry years (28% reduction to 105 days)	Decrease in number of days with suitable conditions for adult migration in normal (11% reduction to 55 days), dry (20% reduction to 47 days) and critical dry years (32% reduction to 40 days)	Access to 25.8 miles of anadromous steelhead habitat in the mainstem and substantial additional miles in tributaries; up to 6 miles in the mainstem for coho and 20.8 in tributaries	Install 20 "notched" rock weirs, anchored LWD and/or off-set wood or rock structures to focus low flows, and improve conditions for resting and rearing, along ~1 mile between Tait Street and Water Street	20	$ 1,202,941

	Decrease in number of days with suitable conditions for smolt migration in critical dry years (28% reduction to 105 days)	Decrease in number of days with suitable conditions for smolt migration in critical dry years (28% reduction to 105 days)		Remove or modify 2 mainstem San Lorenzo River dams (Lewis & Barker) plus 1 tributary dam to improve movement throughout the system during dry years.	3	$ 682,425
San Lorenzo downstream of the Felton Diversion[5]	Flow reductions during early rearing period (April, May) in dry years (7.5% reduction)	Flow reductions during early rearing period (April, May) in dry years (7.5% reduction)	Up to 7 miles of riverine habitat down to Tait Street could be affected in dry years	Work with partners to identify, design, and implement 5 permanent instream flow improvement projects on the middle reach of the San Lorenzo River to increase instream flows during April, May and into the summer to improve rearing.	5	$ 500,000
Newell Anadromous[6]	Decrease in number of days with suitable conditions for adult migration in normal (15% reduction to 37 days), dry (44% reduction to 9 days) and critical dry years (76% reduction to 1 day)	Decrease in number of days with suitable conditions for adult migration in wet (21% reduction to 24 days), normal (38% reduction to 14 days), dry (52% reduction to 1 day) and critical dry years (67% reduction to 0 days)	About 1 mile of anadromous habitat	<u>Branciforte Creek as a Proxy for Newell Cr</u>		
				Remove Casa de Montgomery dams and develop a fish friendly replacement diversion to open up passage to 4-5 miles of anadromous stream.	2	$ 606,600

	Decrease in WUA for spawning in normal (9% reduction), dry (21% reduction) and critical dry years (34% reduction)	Decrease in WUA for spawning in dry (20% reduction) and critical dry years (42% reduction)	Total of 21 potential spawning locations with maximum 1095 square feet of useable habitat (24 sq. ft. per 100 ft. of stream)		Install 12 anchored LWD structures at appropriate locations to improve spawning gravel sorting and increase square footage of spawning by ~100 sf per site (1200 sf in total)	12	$ 220,712
					Remove 4 additional high and medium priority passage obstructions (all small) along Branciforte Cr to enable unimpeded passage	4	$ 210,804
	Decrease in number of days with suitable conditions for smolt migration in normal (13% reduction to 42 days), dry (35% reduction to 14 days) and critical dry years (80% reduction to 1 day)	Decrease in number of days with suitable conditions for smolt migration in normal (13% reduction to 42 days), dry (35% reduction to 14 days) and critical dry years (80% reduction to 1 day)	About 1 mile of anadromous habitat		Cost-share planning and implementation of passage improvement on upper 1/3 of FCC to enable access across a range of migration flows through the channel	flat fee	$ 1,000,000
						TOTAL	***$8,011,479***[7]

[1] A proxy is used to firstly, put conservation effort into streams that are higher recovery priorities and secondly, provide options for conservation work when those opportunities may be limited in the watershed where the residual biological effect occurs. Proxies are intended to be adjacent, similar watersheds when possible.

[2] Ecological Portfolios are designed as concepts and are not meant to be interpreted as prescriptive, NFCF projects will be determined by the TAC based on opportunities available and perceived benefits in real time.

[3] No residual effects on coho in Laguna Creek of 5% or more; no suitable habitat for coho in Liddell and Majors Creeks; no suitable rearing habitat for coho downstream of the Tait Street Diversion.

[4] Reductions in adult and smolt migration opportunities at this location may not translate into significant biological effects since there is still a substantial period when migration criteria are still met.

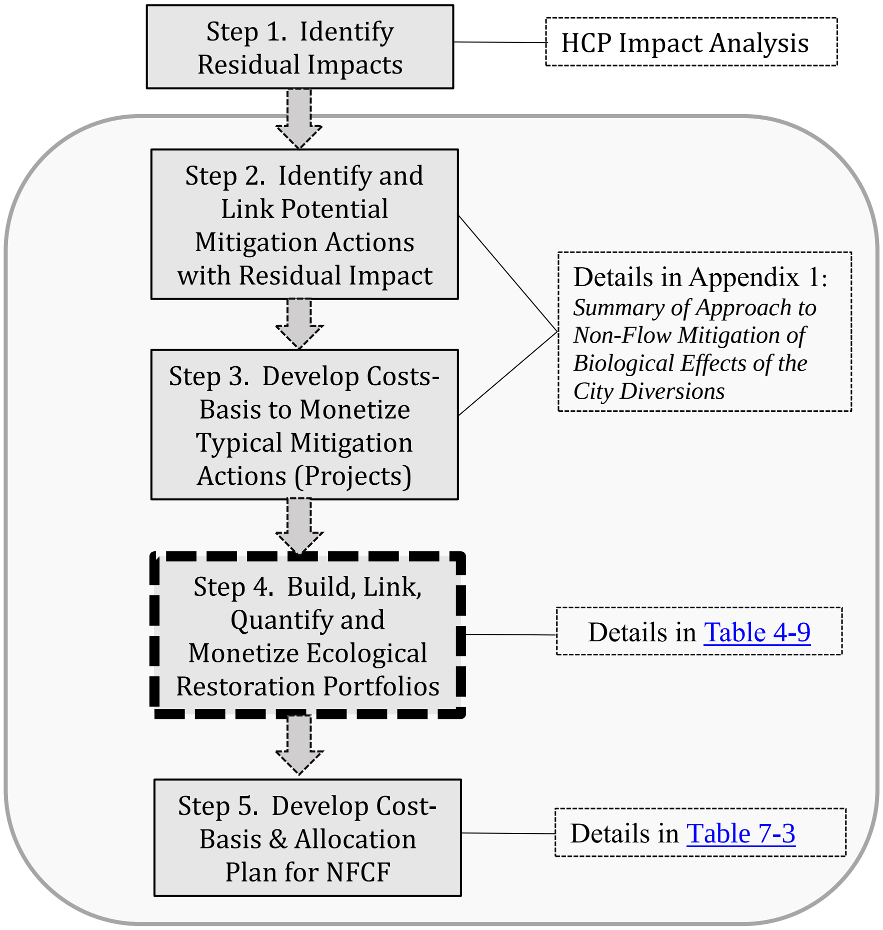
[5] Spawning and rearing values downstream of the Felton Diversion based on hydrology only.

[6] All residual effects largely determined by spill frequency.
[7] Includes administrative and permitting costs.

4.5.4 Developing the Process and Data to Support the NFCF

Figure 4-1 describes the 5-step process utilized to develop the NFCF, which starts with identifying residual impacts and culminates with a translation of appropriate mitigation into a quantitative metric – dollars. Appendix 1: *Summary of Approach to Non-Flow Mitigation of Biological Effects of the City Diversions* provides a series of tables that were used to support development of the NFCF. The two critical components that provide the foundation for the NFCF are the development of the ecological portfolios and the translation of the portfolios into dollars.

Figure 4-1: Flowchart for Quantifying and Monetizing Impacts and Mitigation through the Ecological Restoration Portfolio Approach



4.5.4.1 Developing Ecological Portfolios

Creating the portfolio requires identification of a suite of projects or actions that would directly mitigate for potential residual impacts. The portfolios were developed using a combination of quantitative tools (e.g. relative size or location of the residual impacts) and qualitative tools. The qualitative tools are based on known site conditions, opportunities for meaningful improvement of conditions for fisheries, and professional judgement. While most of the portfolios are focused on directly mitigating residual impacts in the impacted reaches, for Newell Creek the mitigation could occur in Branciforte Creek, and for Liddell Creek and Majors Creek, the mitigation would occur in San Vicente Creek. These particular streams were used as proxies for the impacted reaches because (a) the level of potential residual impact resulting from implementation of the HCP in Newell Creek makes it a more difficult stream for implementing meaningful mitigation actions and (b) higher priority recovery streams exist in nearby watersheds that may provide greater mitigation opportunities and benefits for both coho and steelhead. The replacement portfolio streams either currently support steelhead and coho (San Vicente Creek) or support steelhead and are a priority for coho recovery (Branciforte Creek).

It is critical to emphasize that these portfolios were designed to enable a realistic quantification and monetization of mitigation costs and they were not designed to be prescriptive as to exactly what mitigation should be implemented with the NFCF funding. While the projects within each portfolio have been identified based on the residual impacts, local conditions, and known limiting factors, they do not take into consideration a number of critical externalities (e.g. flood management, access, ownership, recovery priority, etc.) that could affect the ability or the desire to implement a given conservation project.

4.5.4.2 Translating Ecological Portfolios into Dollars

Development of locally appropriate costs for implementing the ecological portfolios is a critical step for monetizing each portfolio in 2018 dollars. While there are a number of sources in the literature that provide ranges of costs for an array of restoration practices, this effort focused on using locally and regionally available data from 15 years of the Integrated Watershed Restoration Program (IWRP). Finally, in situations where IWRP data was not available, the database has been completed with additional data compiled through (a) personal communication with local experts; (b) professional experience; and (c) consulting and cross-referencing with NOAA’s 2008 Technical Memorandum Habitat Restoration Cost References for Salmon Recovery Planning by Thomson and Pinkerton. Appendix 1: *Summary of Approach to Non-Flow Mitigation of Biological Effects of the City Diversions* contains tables with known costs and an average cost-basis for a suite of restoration actions that could be implemented as part of the NFCF.

5.0 ASSESSMENT OF EFFECTS AND LEVEL OF TAKE

The ESA requires that an HCP provide an estimate of the effects anticipated to result from the proposed covered activities. This chapter provides an estimate of the effects anticipated to occur to steelhead and coho from implementation of the conservation strategy and the Covered Activities. Effects were evaluated in the context of existing habitat conditions and conditions expected over the life of the Plan under changing climate scenarios.

Incidental take is estimated in terms of numbers of individuals for activities that potentially result in direct take of steelhead or coho life-stages and where there is an estimate of abundance for relevant life-stages and a rational basis for estimating potential effects. An example of such a situation would be related to the monitoring program which proposes seining surveys in the San Lorenzo and Laguna Creek lagoons. It is possible to estimate average or maximum numbers that may be caught and to assume an average mortality rate related to this activity. Other activities where this approach may be appropriate include such activities as sediment removal in the flood-control channel where the work area is dewatered and fish are relocated.

Incidental take can be quantified in a number ways, such as numbers of affected individuals, nesting groups, or a surrogate measure like acres of habitat or stream miles. Numbers of individuals, nesting territories, breeding pairs, etc. often come to mind first, but it is not always practical to survey and count affected wildlife populations directly. More often we use a surrogate measure, such as acres of habitat or a measurable ecological condition that we define and use to express incidental take authorized by a permit (USFWS and NMFS 2016). The majority of potential effects of the City’s activities involve modification of stream flows below diversion facilities. Take related to this activity is indirect and, in many cases temporary or transient. For example, reduction of flow during the rearing period in dry years may hypothetically result in lower feeding rates at certain times and locations, reduced growth rates, and increased risk of predation due to smaller size at ocean entry. None of these hypothetical processes is sufficiently understood or quantified to provide meaningful estimation of take. It is possible to provide quantitative estimates for changes in length of potential migration periods and changes in habitat quantity/quality for spawning and rearing (WUA) but there is not, at this time, a rationally defensible method to convert these metrics into numbers of fish. The best scientific and commercial data available are not sufficient to enable the City to estimate a specific amount of incidental take of CCC steelhead or CCC coho related to operation of the diversion facilities. Therefore, the habitat conditions (expressed as WUA for spawning or rearing and migration days) for various steelhead and coho life stages that would result from implementation of the HCP shall serve as an ecological surrogate for the anticipated amount of incidental take associated with the ongoing operation of the City’s diversions.

The bypass flows adopted as part of the avoidance and minimization measures for the diversion activities are still expected to have an associated level of incidental take, which will be fully offset through compensatory mitigation. The Conservation Strategy (Chapter 4), was developed in close coordination with the National Marine Fisheries Service and the California Department of Fish and Wildlife, and it is anticipated that implementation of the avoidance, minimization and mitigation measures in the Conservation Strategy will contribute to the conservation of the Covered Species.

5.1 Effects of Covered Activities

5.1.1 Steelhead

Activities with residual effects to steelhead after implementation of the Covered Activities and the conservation strategy are summarized in Table 5-1. Residual effects from the Covered Activities are largely confined to habitat effects downstream of diversions, primarily in Liddell Creek and Majors Creek in dry and critically dry years; downstream of the Tait Street diversion in critically dry years; habitat effects in Newell Creek; effects of capture and relocation during instream projects; and monitoring. Residual effects are quantified in Section 5.2.

Table 5-1: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Steelhead. Remaining Effects are Relative to No City Diversion

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Water Supply Operations: Water Diversions			
Liddell Spring Diversion	Flow reduction	• Implement minimum stream-flow targets • Implement ramping rates	• Reduction in average adult migration days in dry and critically dry years by up to 42% (17 days) in dry years and 40% (6 days) in critically dry years • Reduction in average spawning habitat index by up to 30% in dry years and 38% in critically dry years • Reduction in average summer rearing habitat index by up to 44% in critically dry years and 40% in dry years • Reduction in average smolt migration days by up to 56% in critically dry years (79 days) and 35% in dry years (53 days)
Laguna/Reggiardo Creek Diversion	Flow reduction	• Implement minimum stream-flow targets • Implement ramping rates	• Slight reduction in spawning habitat index in wet and normal years (6%) • Up to 17% average reduction in rearing habitat index in wet years; 2% or less reduction in dry and critically dry years
	Lagoon water quality	• Implement minimum stream-flow targets	None
Majors Creek Diversion	Flow reduction	• Implement minimum stream-flow targets	• Reduction in average spawning habitat index by 3% in wet years up to 24% in critically dry years • Reduction in average rearing habitat index by 21% to 24%

		• Implement ramping rates	• Reduction in average smolt migration days up to 14.5% (3 days) in dry years
Newell Creek Diversion	Flow reduction	• Existing instream flow requirements • Implement ramping rates	• Reduction in average adult migration index by 35% in dry years; and 89 % (from 5 days to 1 day) in critically dry years • Reduction in average spawning habitat index by 16% in dry years up to 34% in critically dry years • Net positive effect on rearing habitat index with up to 7% reduction in spring of normal years but 8.5 % increase in critically dry springs and increase in summer by 13%, 27%, and 33% in normal, dry, and critically dry years respectively • Reduction in smolt migration index by 23% in dry years (21 days to 14 days) and by 80% in critically dry years (from 5 days to 1 day)
	Temperature effects	Maintain temperature below 21° during warm spill	None
Felton Surface Water Diversion at San Lorenzo River	Flow reduction	• Existing instream flow requirements • Implement ramping rates	• Reduction in average spawning habitat index by 3% in dry years and 6% in critically dry years • Maximum 1.3% reduction in average rearing habitat index
	Sedimentation	• Existing operating agreements	None
	Fish Passage at diversion	• Existing operating agreements, BMPs, and SOPs • Install fish screen and	None

		passage upgrades	
Tait Street Diversion and Wells	Flow reduction	- Implement minimum stream-flow targets - Implement ramping rates	- Reduction in average adult steelhead migration in critically dry years of 13% (18 days) - Up to 16% reduction in rearing habitat index during summer of dry and normal years - Reduction in average smolt migration days in critically dry years by 8.5% (13 days)
	Lagoon water quality	- Implement minimum stream-flow targets	Average reduction in summer lagoon inflow by up to 42% in dry years
	Fish Passage	- Install fish screen and passage upgrades	None

Table 5-1: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Steelhead. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Water Supply Operations: Reservoir Operations			
Chemical Algaecide Treatment of Reservoir	Copper Toxicity	• Follow label instructions • Aquatic Pesticide Application Plan • Treatment SOPs and BMPs • Adherence to SWRCB NPDES permit • Monitoring plan in place	In compliance with Basin Plan, negligible effect
Testing Deluge and Gate Valves	Low dissolved oxygen Erosion	• SOPs and BMPs including: Aeration at release point • Erosion control measures	None
Woody Debris Removal on Reservoir Face	Eliminate downstream recruitment	• Stockpile larger pieces for habitat restoration projects	Average annual loss of 10 cubic yards woody debris

Table 5-1: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Steelhead. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Water System Operations and Maintenance			
Water Diversion Sediment Management (North Coast)	Sedimentation of downstream habitat	• Sediment removal BMPs and SOPs • Install sediment management upgrades	None
Fish Ladder and Screen Maintenance	None	Fish screen upgrades	None
Conveyance Pipeline System Inspection and Repairs	Turbidity and sedimentation of downstream habitat	Construction SOPs and BMPs	None
Finished Water Pipeline System Flushing and Repairs	Disinfection toxicity (chlorine) Turbidity	• Dechlorination • SOP Nos. 7102-01 and 7102-02 • Supervision by environmental monitor	None
Pumping Well Return to San Lorenzo River	Turbidity and sedimentation	Discharge to decanting basin	None
North Coast Valve Blow Off to San Lorenzo River	Turbidity and sedimentation	Discharge onto rip-rap	None
Dewatering of Creeks for Maintenance and Repairs	Injury or mortality to fish as a result of relocation activities	SOPs for dewatering and fish relocation	Temporary dewatering with capture and relocation of up to 600 steelhead with incidental mortality of 18 steelhead

Table 5-1: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Steelhead. Remaining effects are relative to no City diversion (Continued)

Commented [CB3]: Needs formatting

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Municipal Facility Operations and Maintenance			
Flood Control Debris/Obstruction Removal	Habitat simplification	• Supervision by environmental monitor • BMPs and SOPs for streamside projects	Some loss of habitat structural elements, mostly in lagoon
Flood Control Sediment Management/Removal	Temporary habitat disruption, Turbidity, Direct mortality	• Fish removal and protection during operations. • SOPs for dewatering and fish relocation. • Preventive maintenance for storm drains	• Sediment removal without dewatering in San Lorenzo main channel. • Relocation of 62 steelhead with incidental mortality of 2 steelhead during each of six events in the Branciforte FCC (every 5 years)
Flood Control Vegetation Management	Loss of habitat components- cover, shading; increased temperature; reduced productivity	• Avoid work in wetted channel • Avoid removal of mature trees except in FCCs • Buffer strips in FCC	Minor degradation of riparian habitat
Stormwater Maintenance	Discharge of pollutants Increased peak storm flows	• SWMP, Measure E, Stormwater BMPs • Storm drain inspection and cleaning	None

	Reduced infiltration to ground	• Structural retrofits and storm drain inlets and basins	
Stormwater BMPs	Discharge of pollutants	• Stormwater Management Program • Stormwater BMPs	None

Table 5-1: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Steelhead. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Municipal Facility Operations and Maintenance (continued)			
Storm Drain Inspection and Cleaning	Discharge of pollutants	Storm drain inspection and cleaning	None
Structural Retrofits of Storm Drain Inlets and Basins	Discharge of pollutants	Dry weather diversion to WTP Inline treatment systems	None
Sanitary Landfill Stormwater Management	Discharge of pollutants	• Bypass system and stormwater outfall • Sediment management of bypass ponds • Leachate management	None
Emergency Operations and Response	Negligible potential effects on anadromous fish		None
Vegetation Management Within Riparian Corridors	Negligible potential effects on anadromous fish	Integrated Pest Management program	None

Table 5-1: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Steelhead. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Land Management			
Loch Lomond Recreation Area and Watershed Lands	Negligible potential effects on anadromous fish	BMPs for work near streams	None
Trail Maintenance and Repair	Negligible potential effects on anadromous fish	BMPs for work near streams	None
Road Maintenance and Decommissioning	Sediment delivery	• Work in dry season • Work supported by Certified Erosion Control Specialist • Maintenance of appropriate drainage to avoid erosion potential • Out-sloping, rolling dips, water bars, winter closures, rocking • Road decommissioning • Conduct timber harvest solely for restoration or forest resiliency purposes	None

Aquatic Habitat Management	• Temporary habitat disturbance • Fish relocation	• Work under permit conditions • BMPs and SOPs for work near streams • Work conducted during dry season with SOPs and BMPs for in-channel work • Post-project monitoring	• Beneficial effects of habitat improvement • Temporary dewatering with capture and relocation of up to 4,500 steelhead over term of HCP with incidental mortality of up to 135 steelhead

Table 5-1: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Steelhead. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
HCP Monitoring Program			
Compliance Monitoring	No potential effects on anadromous fish	None needed	None
Juvenile Abundance – Riverine	Potential effects from capture by electrofishing, examination, holding, tagging	Standard fish sampling protection measures	• Observation of up to 1,500 juvenile steelhead, 5 adult steelhead annually in snorkel surveys • Capture and tagging of up to 2,000 juvenile steelhead annually in electrofishing surveys with incidental mortality of up to 60 steelhead
Juvenile Abundance – Lagoons	Potential effects from capture by seine, examination, holding, tagging	Standard fish sampling protection measures	Capture and tagging of up to 12,700 juvenile steelhead annually in lagoon abundance surveys with incidental mortality of up to 254 steelhead
Adult Abundance	Potential effects from capture in the Felton Diversion fish trap, holding, examination, tagging	Standard fish sampling protection measures	Capture and tagging of up to 3,000 adult steelhead with incidental mortality of up to 30 adult steelhead
PIT Tag Monitoring Antenna	No potential effects	None needed	None
Habitat Assessment	No potential effects	None needed	None

5.1.2 Coho

Residual effects of Covered Activities that could occur to coho, after application of avoidance and mitigation measures, are summarized in Table 5-8. Coho do not currently maintain viable, self-sustaining populations in the Plan Area. However, to inform the goals and objectives that are designed to provide conditions that would support the reestablishment of coho populations in the Plan Area, effects on coho are described hypothetically and are dependent on re-establishment of coho in the Plan Area. Potential residual effects are limited to habitat effects downstream of the Tait Street diversion in critically dry years, habitat effects in Newell Creek, effects of capture and relocation during instream projects, and monitoring. Residual effects are quantified in Section 5.2.

Table 5-2: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Coho. Remaining Effects are Relative to No City Diversion

Commented [CB4]: Needs formatting

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Water Supply Operations: Water Diversions			
Liddell Spring Diversion	N/A Liddell Creek is not considered coho habitat		None
Laguna/Reggiardo Creek Diversion	Flow reduction	• Implement minimum stream-flow targets • Implement ramping rates	• Reduction in average spawning index of up to 2% in normal years • Less than 1 day average reduction in smolt migration index in all year types
	Lagoon not considered coho habitat	• Implement minimum stream-flow targets	None
Majors Creek Diversion	N/A Majors Creek is not considered coho habitat		None
Newell Creek Diversion	Flow reduction	• Existing instream flow requirements • Implement ramping rates	• Reduction by 2-4 days annually in average adult migration index: 3 days in normal years; from 3.5 days to 1.2 days in dry years; and from 2 days to 0 days (100%) in critically dry years • Reduction in average spawning habitat index by 15% in dry years and 36% in critically dry years • Increase in average rearing habitat index in critically dry spring by 2%; increase in summer by 3%, 5%, and 7% in normal, dry, and critically dry years respectively • Reduction in smolt migration index by 23% in dry years (21 days to 13.5) and by 80% in critically dry years (from 5 days to 1 day)

Felton Surface Water Diversion at San Lorenzo River	Flow reduction	• Existing instream flow requirements • Implement ramping rates	None
	Sedimentation	• Existing operating agreements	None
	Fish Passage at diversion	• Existing operating agreements, BMPs, and SOPs • Install fish screen and passage upgrades	None
Tait Street Diversion and Wells	Flow reduction	• Implement minimum stream-flow targets • Implement ramping rates	• Reduction in average adult migration index of up to 10% in critically dry years • Reduction in average smolt migration index by up to 8.5% in critically dry years
	Lagoon water quality	• Implement minimum stream-flow targets	None
	Fish Passage	• Install fish screen and passage upgrades	None

Table 5-2: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Coho. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Water Supply Operations: Reservoir Operations			
Chemical Algaecide Treatment of Reservoir	Copper Toxicity	• Follow label instructions • Aquatic Pesticide Application Plan • Treatment SOPs and BMPs • Adherence to SWRCB NPDES permit • Monitoring plan in place	In compliance with Basin Plan, negligible effect
Testing Deluge and Gate Valves	Low dissolved oxygen Erosion	SOPs and BMPs including: • Aeration at release point • Erosion control measures	None
Woody Debris Removal on Reservoir Face	Eliminate downstream recruitment	• Stockpile larger pieces for habitat restoration projects	Average annual loss of 10 cubic yards woody debris

Table 5-2: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Coho. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Water System Operations and Maintenance			
Water Diversion Sediment Management (North Coast)	Sedimentation of downstream habitat	• Sediment removal BMPs and SOPs • Install sediment management upgrades	None
Fish Ladder and Screen Maintenance	None	Fish screen upgrades	None
Conveyance Pipeline System Inspection and Repairs	Turbidity and sedimentation of downstream habitat	Construction SOPs and BMPs	None
Finished Water Pipeline System Flushing and Repairs	Disinfection toxicity (chlorine) Turbidity	• Dechlorination • SOP nos. 7102-01 and 7102-02 • Supervision by environmental monitor	None
Pumping Well Return to San Lorenzo River	Turbidity and sedimentation	Discharge to decanting basin	None
North Coast Valve Blow Off to San Lorenzo River	Turbidity and sedimentation	Discharge onto rip-rap	None
Dewatering of Creeks for	Injury or mortality to fish as a result of relocation activities	SOPs for dewatering and fish relocation	Temporary dewatering with capture and relocation of undefined number of juvenile

Maintenance and Repairs			coho, if re-established; incidental direct mortality of up to 3%

Table 5-2: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Coho. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Municipal Facility Operations and Maintenance			
Flood Control Debris/Obstruction Removal	Habitat simplification	• Supervision by environmental monitor • BMPs and SOPs for streamside projects	None, habitat not suitable for coho even if re-established
Flood Control Sediment Management/Removal	Temporary habitat disruption, Turbidity, Direct mortality	• Fish removal and protection during operations. • SOPs for dewatering and fish relocation. • Preventive maintenance for storm drains.	None, habitat not suitable for coho even if re-established
Flood Control Vegetation Management	Loss of habitat components- cover, shading; increased temperature; reduced productivity	• Avoid work in wetted channel • Avoid removal of mature trees except in FCCs	• Minor degradation of riparian habitat • May affect migrating smolts if re-established

		- Buffer strips in FCC	
Stormwater Maintenance	Discharge of pollutants Increased peak storm flows Reduced infiltration to ground	- SWMP, Measure E, Stormwater BMPs - Storm drain inspection and cleaning - Structural retrofits and storm drain inlets and basins	None
Stormwater BMPs	Discharge of pollutants	- Stormwater Management Program - Stormwater BMPs	None
Storm Drain Inspection and Cleaning	Discharge of pollutants	- Storm drain inspection and cleaning	None
Structural Retrofits of Storm Drain Inlets and Basins	Discharge of pollutants	- Dry weather diversion to WTP - Inline treatment systems	None

Table 5-2: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Coho. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Municipal Facility Operations and Maintenance (continued)			
Sanitary Landfill Stormwater Management	Discharge of pollutants	• Bypass system and stormwater outfall • Sediment management of bypass ponds • Leachate management	None
Emergency Operations and Response	Negligible potential effects on anadromous fish		None
Vegetation Management Within Riparian Corridors	Negligible potential effects on anadromous fish	• Integrated Pest Management program	None

Table 5-2: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Coho. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
Land Management			
Loch Lomond Recreation Area and Watershed Lands	Negligible potential effects on anadromous fish	BMPs for work near streams	None
Trail Maintenance and Repair	Negligible potential effects on anadromous fish	BMPs for work near streams	None
Road Maintenance and Decommissioning	Sediment delivery	• Work in dry season • Work supported by Certified Erosion Control Specialist • Maintenance of appropriate drainage to avoid erosion potential • Out-sloping, rolling dips, water bars, winter closures, rocking • Road decommissioning • Conduct timber harvest solely for restoration or forest resiliency purposes	None
Aquatic Habitat Management	Temporary habitat disturbance, fish relocation	• Work under permit conditions • BMPs and SOPs for work near streams • Work conducted during dry season with SOPs and BMPs for in-channel work • Post-project monitoring	Beneficial effects of habitat improvement; Temporary dewatering with capture and relocation of up to 750 juvenile coho, if re-established; incidental direct mortality of up to 3%

Table 5-2: City Activities, Avoidance and Minimization Measures, and Remaining Effects to be Mitigated for Coho. Remaining effects are relative to no City diversion (Continued)

City Activity	Potential Effect	Avoidance and Minimization Measures	Residual Effects to be Mitigated in NFCF
HCP Monitoring Program			
Compliance Monitoring	No potential effects on anadromous fish	None needed	None
Juvenile Abundance-Riverine	Potential effects from capture by electrofishing, examination, holding, tagging	Standard fish sampling protection measures	If re-established: • Observation of up to 100 juvenile coho annually in snorkel surveys • Capture and tagging of up to 500 juvenile coho annually in electrofishing surveys with incidental mortality of up to 15 coho
Juvenile Abundance-Lagoons	Potential effects from capture by seine, examination, holding, tagging	Standard fish sampling protection measures	If re-established: capture and tagging of up to 200 juvenile coho annually in lagoon abundance surveys with incidental mortality of up to 4 coho
Adult Abundance	Potential effects from capture in the Felton Diversion fish trap, holding, examination, tagging	Standard fish sampling protection measures	• Capture and tagging of up to 10 adult coho If re-established, capture and tagging of up to 200 coho with incidental mortality of up to 2 adult coho
PIT Tag Monitoring Antenna	No potential effects	None needed	None
Habitat Assessment	No potential effects	None needed	None

5.2 Effects of Water Supply Operations – Water Diversions

5.2.1 Steelhead

Steelhead habitat exists below each of the City water diversion locations. This section describes the residual effects to steelhead from HCP bypass flows at the City's diversions after application of avoidance and minimization measures (Chapter 4). Water diversions are the Covered Activity with the greatest potential effect on Covered Species. Although the effects of water diversions are greatly minimized through bypass flows, some residual effects remain. Those effects are described in the rest of this section and summarized in Table 5-1 (steelhead) and Table 5-2 (coho).

As described in Chapter 4, effects are evaluated through use of linked hydrologic and habitat models. Effects on habitat through flow modifications may result in disruption of adult migration patterns; alteration of spawning behavior including reduced spawning success, changes in embryo survival and emergence of fry from spawning gravels; alteration of growth rates and survival rates of rearing juveniles; changes in the numbers of smolts produced; changes in ability of juveniles to migrate within streams and ability of smolts to reach the ocean.

Changes in actual abundance (numbers of individuals) of any life stage cannot be quantitatively linked in any reliable way to changes in flow due to lack of data and lack of rigorous analytical frameworks. Therefore, incidental take cannot be predicted in terms of precise numbers of fish. Instead, surrogate measures of take in terms of habitat metrics are relied upon. These include the number of days during annual cycles with conditions suitable for migration of adults or smolts, an index of habitat suitability for spawning, and an index of habitat suitability for rearing. Habitat metrics for spawning and rearing are expressed in units of WUA calculated through application of the PHABSIM methodology (see HES 2014b for a technical discussion of the development of these indices). In a few cases, change in flow itself is used as a surrogate for incidental take.

Habitat conditions for various steelhead life stages that would result from implementation of the City's operations and bypass flow prescriptions are expressed as changes measured against habitat conditions with no City diversion. These changes will serve as an ecological surrogate for the anticipated amount of incidental take associated with the on-going operation of City facilities and diversions.

The effects analysis compares three scenarios representing a base hypothetical condition with no City diversions; an existing operations scenario reflecting facilities and flow requirements in place before implementation of the HCP; and an HCP scenario. The existing operations scenario is model output using a reconstructed hydrologic database for the period 1937-2015 as input (data generated by Balance Hydrologics), and assuming unconstrained City diversions using existing facilities and operating procedures and 2010 level of demand. The "no-diversion" scenario is the hydrologic database with no City diversion. The HCP bypass flows are as described in Section 4.4.2.1 and assume implementation of the proposed Santa Cruz Water Rights Project (as described in Section 6.2.1) to enhance the City's operational flexibility. Effects are evaluated for each of the four City year type classifications because of the wide variability in flow and related habitat metrics between different year types. This gives an indication of the conditions species would encounter over different annual cycles. It is anticipated that operation of the City's diversion facilities in conformance with the associated bypass flow requirements will maintain instream flow conditions in a manner that adequately protects and conserves habitat downstream of City water diversions. If operation of the City's facilities creates flow conditions that deviate from the bypass flow requirements, the anticipated level of effect caused by the conservation strategy would be exceeded.

The level of effects below each diversion reflects the order of priority for habitat enhancement that is expressed in the Conservation Strategy (Chapter 4). Laguna Creek and the lower San Lorenzo River were given top priority because both streams potentially support coho as well as steelhead and both have functional lagoon systems important to production of steelhead. Laguna Creek has the greatest length of stream habitat for the North Coast streams. The San Lorenzo River is identified as a focus population in the Central California Coast Coho Recovery Plan (NMFS 2012). Newell Creek had the lowest priority due to degraded habitat from residential development and because increased reliance on Loch Lomond Reservoir is required to provide the flows in the higher priority reaches.

Liddell Creek

The Liddell Creek Diversion influences 1.2 miles of anadromous habitat in Liddell Creek including about 0.24 miles downstream of the confluence with the West Branch. Under the HCP, habitat effects are minimized in Liddell Creek through bypass flows in normal and wet years. HCP bypass flows result in improved habitat indices relative to existing conditions in all year types. The average adult migration index in normal and wet years is at least 93% of no-diversion levels (Figure 5-1). In dry and critically dry years, the index is increased by up to 15% relative to existing conditions to at least 57% of no-diversion levels. Similarly, the spawning index with HCP bypass flows is at least 91% of no-diversion levels in normal and wet years and is increased in dry and critically dry years by up to 18% to at least 62% of no-diversion levels (Figure 5-2). The rearing index is increased with HCP bypass flows in normal and wet years by up to 18% from existing conditions to at least 78% of no-diversion levels (Figure 5-3). In dry and critically dry years, the rearing index is increased from existing operations by up to 10% to at least 56% of no-diversion levels. The average smolt migration index in normal and wet years is at least 94% of no-diversion levels (Figure 5-4). In critically dry years the index is increased by more than 150% relative to existing conditions to 44% of no-diversion levels.

Figure 5-1: Effects of Water Diversions on Steelhead Migration in Liddell Creek

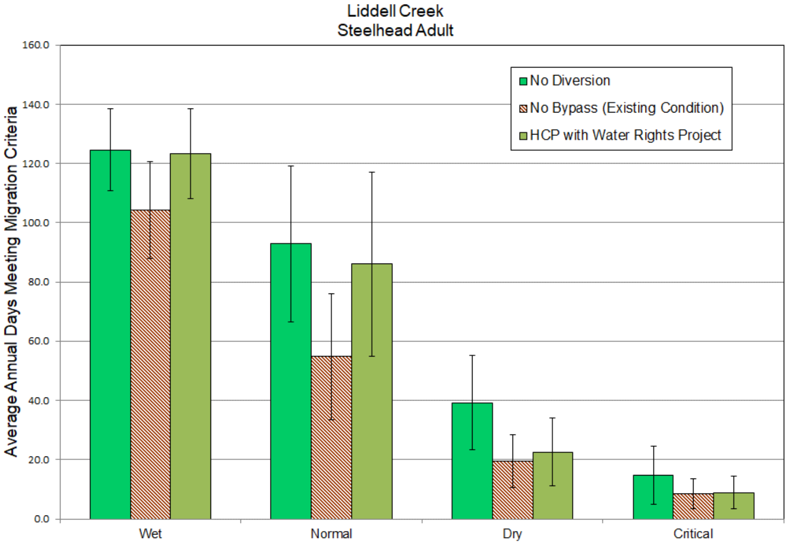


Figure 5-2: Effects of Water Diversions on Steelhead Spawning Habitat in Liddell Creek

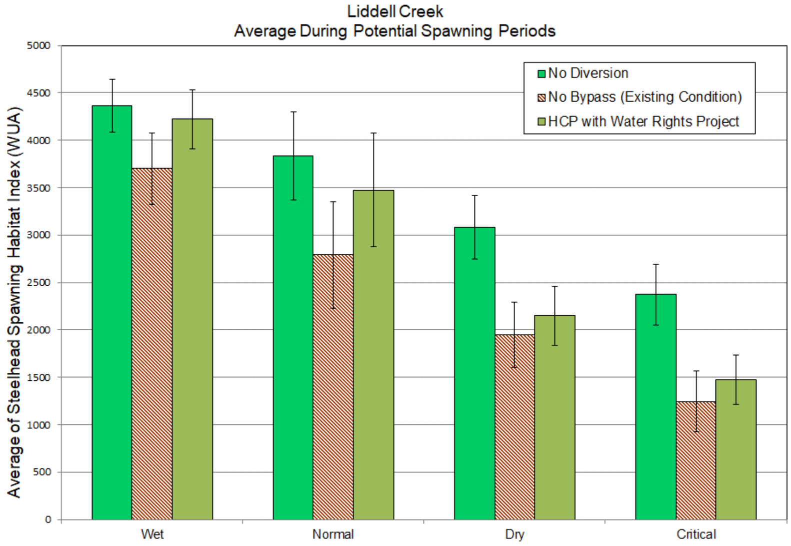


Figure 5-3: Effects of Water Diversions on Steelhead Rearing Habitat in Liddell Creek

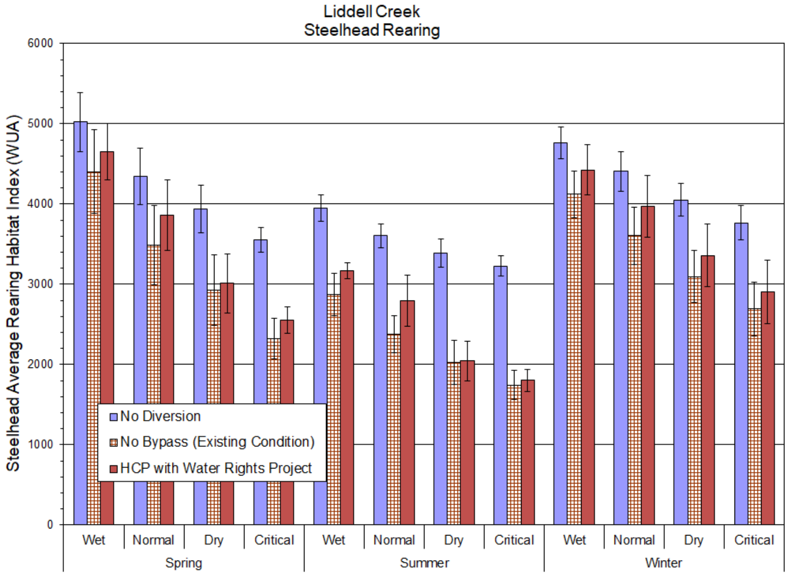
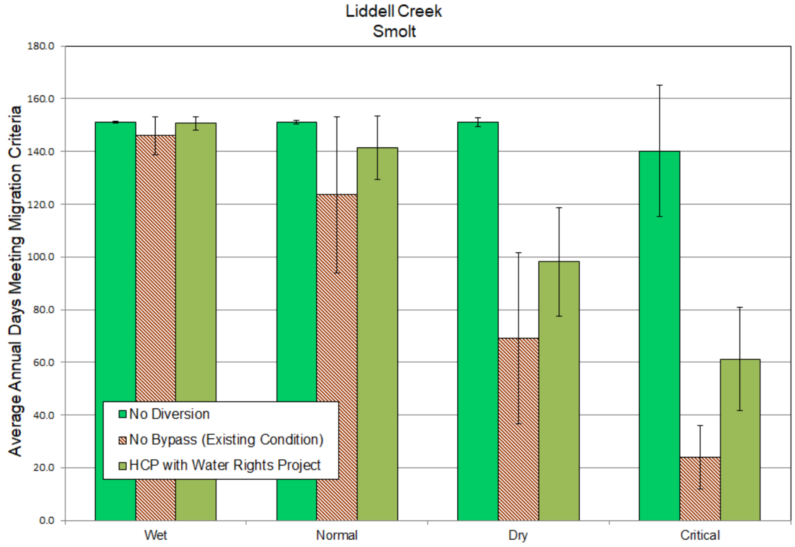


Figure 5-4: Effects of Water Diversions on Steelhead Smolt Migration in Liddell Creek



The largest residual effects occur in dry and critically dry years and include a 43% decrease (-17 days) in the adult migration index in dry years, compared to no-diversion levels, a 38% decrease in the spawning index in critically dry years, 44% decrease in the rearing index in critically dry years, and a 56% decrease (79 days) in the smolt migration index in critically dry years (Table 5-3).

Table 5-3: Residual Effects of HCP Bypass Flows on Steelhead in Liddell Creek

	Steelhead			
	Adult migration	**Spawning/ incubation**	**Rearing**	**Smolt migration**
Wet	-1.1%	-3.2%	-19.7%	-0.4%
Normal	-7.4%	-9.3%	-22.5%	-6.4%
Dry	-42.5%	-30.2%	-39.7%	-35.0%
Critically dry	-39.9%	-37.9%	-44.2%	-56.4%

Laguna Creek

The Laguna Creek Diversion influences all of the 1.4 miles of anadromous habitat in Laguna Creek. Habitat effects for steelhead are substantially avoided in Laguna Creek by providing bypass flows that result in habitat index values that are close to levels that would occur with no City diversions. The average adult migration index under HCP flows is nearly identical to the level in the absence of City diversions and is changed by less than 1 day annually (Figure 5-5). There is some reduction in average spawning habitat values in normal and wet years with decreases of 6% in each compared to no-diversion levels on average (Figure 5-6). The HCP spawning index is at least 94% of the level with no-diversion. The HCP bypass flows result in up to 69% improvement in average WUA for rearing compared to existing operations. WUA with HCP bypass flows is at least 83% of no-diversion levels in all year types (Figure 5-7). The largest percentage reductions compared to no-diversion are in the spring and summer of wet years. The HCP rearing index is nearly identical to the no-diversion index in spring and summer of dry and critically dry years. The smolt migration index is increased from existing operations up to 181% to at least 99% of no-diversion levels in all year types (Figure 5-8). Habitat conditions in Laguna Creek with the HCP are always better than existing conditions for all life-stages. The largest residual effects are a 16% reduction in the rearing habitat index in wet years and a 6% reduction in the spawning habitat index, also in wet years (Table 5-4).

Figure 5-5: Effects of Water Diversions on Steelhead Adult Migration in Laguna Creek

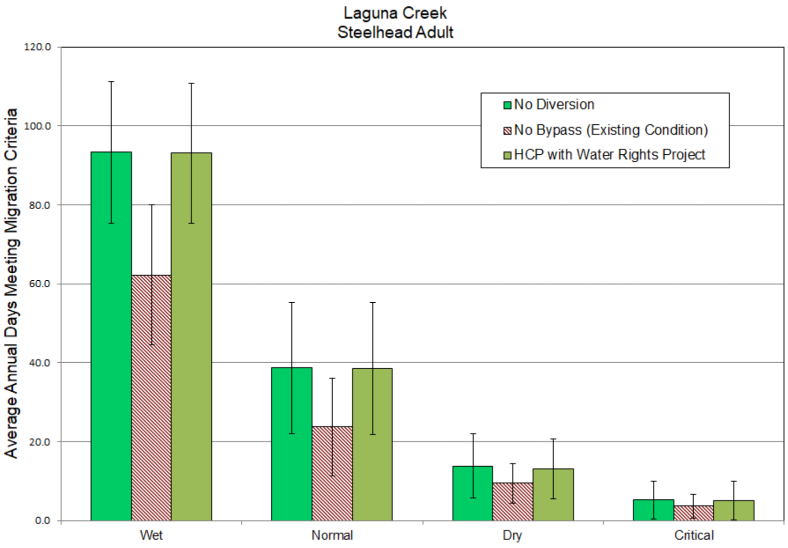


Figure 5-6: Effects of Water Diversions on Steelhead Spawning Habitat in Laguna Creek

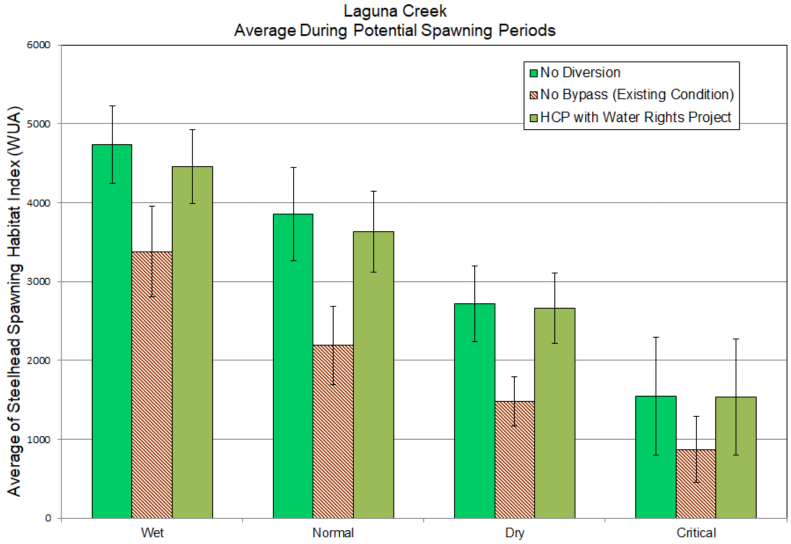


Figure 5-7: Effects of Water Diversions on Steelhead Rearing Habitat Laguna Creek

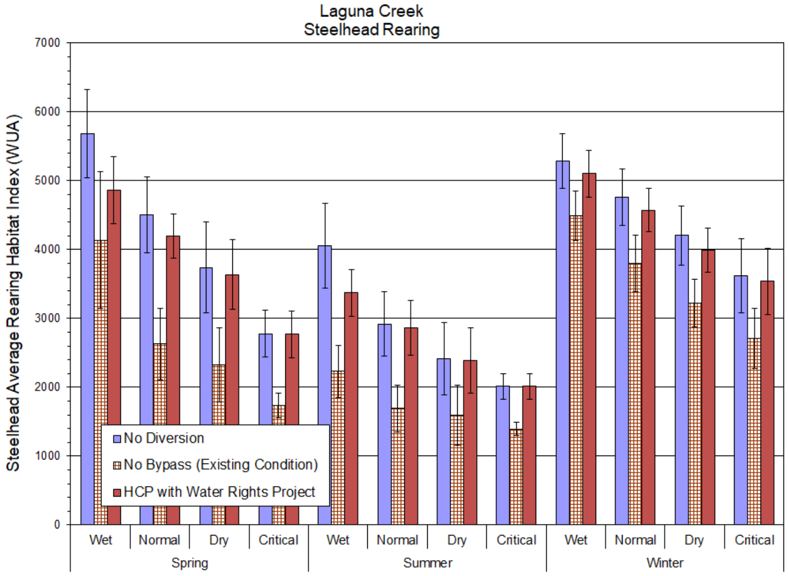


Figure 5-8: Effects of Water Diversions on Steelhead Smolt Migration in Laguna Creek

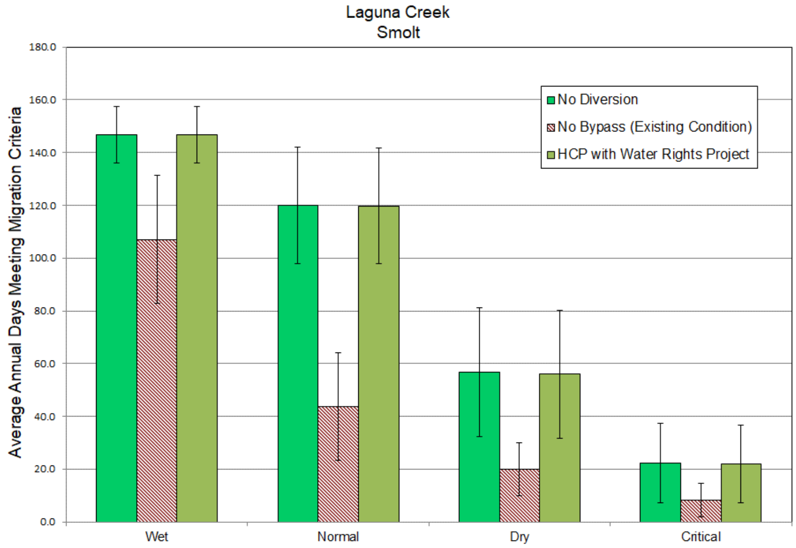


Table 5-4: Residual Effects of HCP Bypass Flows on Steelhead in Laguna Creek

	Steelhead				
	Adult migration	**Spawning / incubation**	**Rearing- spring**	**Rearing- summer**	**Smolt migration**
Wet	*	-5.9%	-14.4%	-16.9%	*
Normal	*	-5.9%	-6.8%	-1.9%	*
Dry	*	-2.1%	-2.8%	-0.9%	*
Critically dry	*	-1.0%	-0.2%	0.0%	*

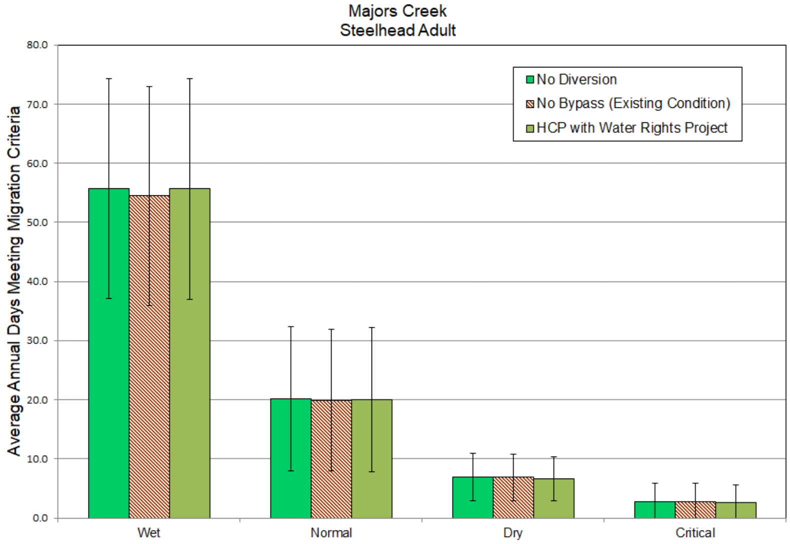
* Difference of 1 day or less

Majors Creek

The Majors Creek Diversion influences all of the approximately 0.7 miles of anadromous habitat in Majors Creek. As in Liddell Creek, habitat effects in Majors Creek are minimized under the

HCP through bypass flows that are highest in normal and wet years, though HCP bypass flows result in improved habitat indices relative to existing conditions in all year types. Model results indicate reduction in the average adult steelhead migration index is less than one day per year under both existing conditions and with HCP bypass flows in all year types[52] (Figure 5-9). The spawning index is increased in normal and wet years to at least 95% of no-diversion levels. In dry and critically dry years, the spawning index is increased by up to 34% to at least 76% of no-diversion levels (Figure 5-10). The Majors Creek steelhead rearing index is increased by up to 50% in normal and wet years to at least 76% of no-diversion levels (Figure 5-11). In dry and critically dry years, the rearing index improves by up to 46% to at least 77% of no-diversion levels. The smolt migration index is improved by up to 35% in normal and wet years to at least 97% of no-diversion levels. In dry and critically dry years, the improvement is 6% or less and the index under the HCP is at least 85% of no-diversion levels (Figure 5-12).

Figure 5-9: Effects of Water Diversions on Adult Steelhead Migration in Majors Creek



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[52] Use of the Majors Creek Diversion is presently limited by the hydraulic loading from the other north coast sources. This means that diversion during higher flow periods is limited and winter habitat conditions for steelhead migration and spawning is less effected by the diversion. The City's long-term plan is to pump this water into the Coast Main so that the hydraulic restriction will no longer limit the diversion. Bypass flows for migration and spawning are still in place for normal and wet years and improvements are expected to have their biggest effect in wet periods.

Figure 5-10: Effects of Water Diversions on Steelhead Spawning Habitat in Majors Creek

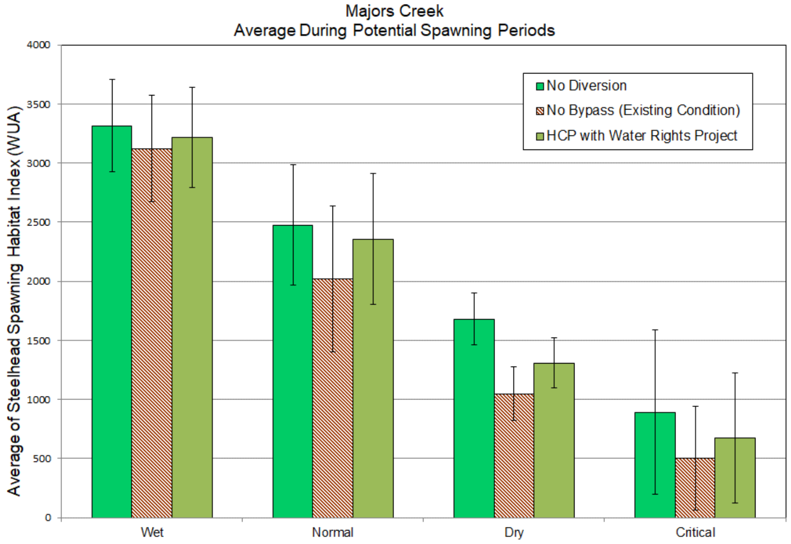


Figure 5-11: Effects of Water Diversions on Steelhead Rearing Habitat in Majors Creek

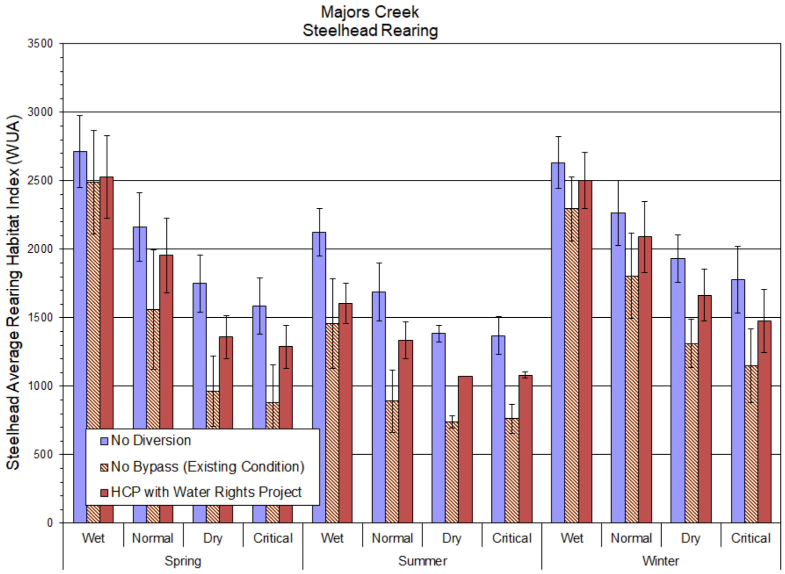
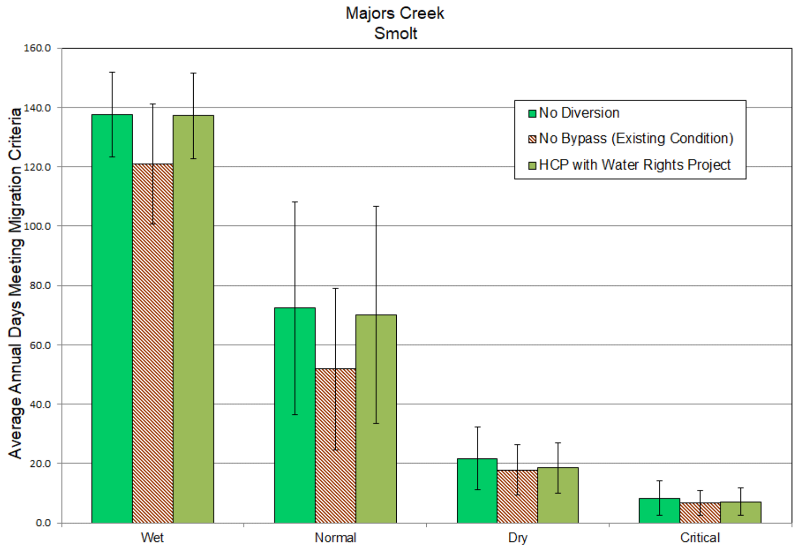


Figure 5-12: Effects of Water Diversions on Steelhead Smolt Migration in Majors Creek



The largest residual effects in Majors Creek include reductions of up to 24% in the spawning habitat index in dry and critically dry years, reductions of 21-24% in the rearing habitat index in all year types, and reductions in the smolt migration index of up to 14% in dry and critically dry years (Table 5-5).

Table 5-5: Residual Effects of HCP Bypass Flows on Steelhead in Majors Creek

	Steelhead			
	Adult migration	**Spawning/ incubation**	**Rearing**	**Smolt migration**
Wet	*	-2.9%	-24.5%	*
Normal	*	-4.8%	-21.0%	-3.1%
Dry	*	-22.1%	-22.7%	-14.5%
Critically dry	*	-24.3%	-21.0%	-14.0%

* Difference of 1 day or less

Newell Creek

Implementation of HCP bypass flows results in somewhat greater fluctuation in storage in Loch Lomond Reservoir with slightly higher storage and more frequent spill during wetter years and lower frequency and duration of reservoir spill in drier conditions, influencing about 1 mile of anadromous habitat in Newell Creek downstream of Newell Creek Dam. Frequency of flows sufficient for adult steelhead migration are reduced compared to no-diversion levels by 0% in wet years, 2% in normal years, 35% in dry years, and 89% (from 5 days to 1 day) in critically dry years (Figure 5-13). The spawning habitat index is reduced by 0.6% in wet years, 2%in normal years, 16% in dry years, and 34% in critically dry years (Figure 5-14). Migration and spawning indices with the Project are not substantially different from Existing Conditions.

The steelhead rearing habitat index is beneficially affected by operation of Loch Lomond Reservoir as a result of the 1 cfs minimum release requirement (Figure 5-15). During the spring (defined here as April, May, and June) the rearing habitat index is reduced by up to 7% in normal years but increased by over 8% on average in critically dry years. During summer (July, August, and September), the wet year habitat index is reduced by 4% but it is increased on average in normal, dry, and critically dry years by 13%, 27%, and 33% respectively (Figure 5-16). The rearing habitat index with the Project is not substantially different from the Existing Condition.

Figure 5-13: Effects of Water Diversions on Adult Steelhead Migration in Newell Creek

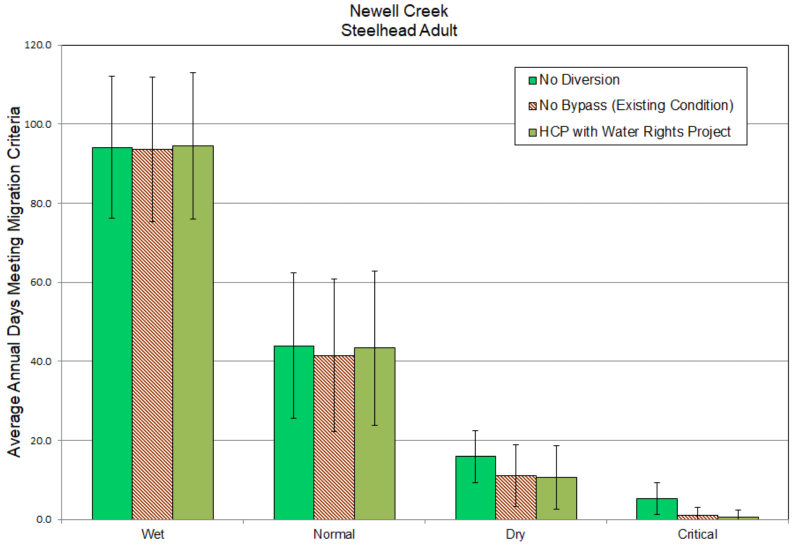


Figure 5-14: Effects of Water Diversions on Steelhead Spawning Habitat in Newell Creek

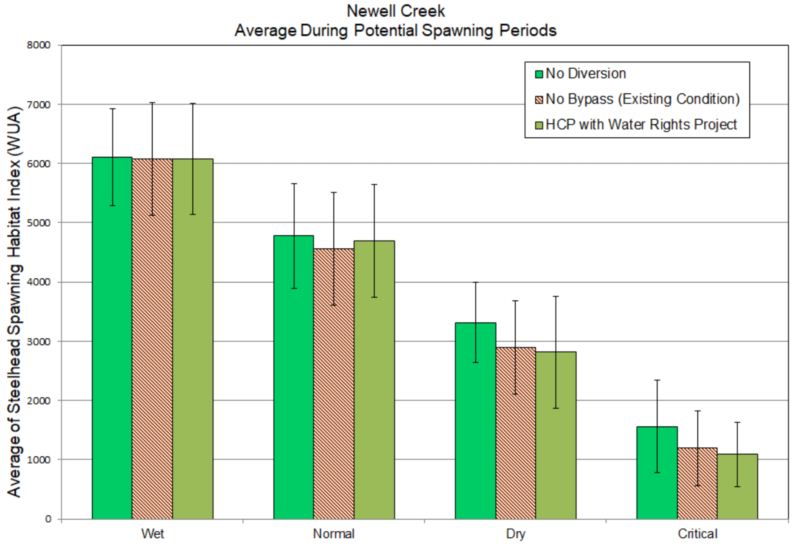
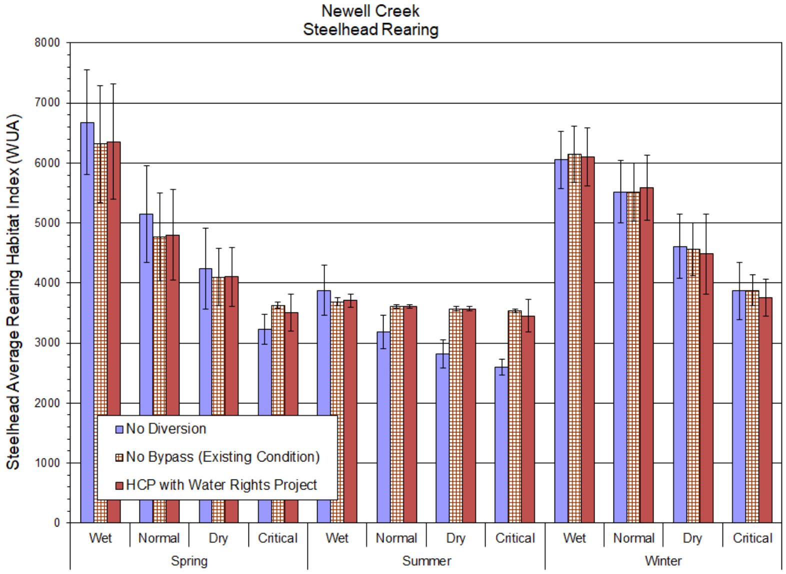


Figure 5-15: Effects of Water Diversions on Steelhead Rearing Habitat in Newell Creek



Flows suitable for smolt migration are reduced by up to 7 days in dry and normal years, 4 days in dry, and 2 days in wet years compared to No-Diversion levels (Figure 5-24). The greatest reductions in percentage terms are in dry years (23% reduction from 21 days to 14) and critically dry years when the average number of days with suitable migration conditions is reduced from 5 days with no diversions to 1 day with HCP flows, an 80% reduction. The smolt migration index with the project is not substantially different than the Existing Condition.

The greatest residual effect for steelhead in Newell Creek is the increase in the rearing habitat index during the spring and summer of drier years relative to the No Diversion scenario. Reductions in adult migration and spawning indices of up to 89% for migration in critically dry years and 34% for spawning, also in critically dry years (Table 5-6), while large in percentage terms are not likely to be biologically significant since the habitat indices are quite low even without the reservoir (No Diversion). The reduction in flows suitable for smolt migration may also be less biologically meaningful since there are very few days in the smolt migration range even without the effect of the reservoir and diversions in dry and critically dry years (21 days and 5 days respectively, out of the 5-month smolt migration period).

Figure 5-16: Effects of Water Diversions on Steelhead Smolt Migration in Newell Creek

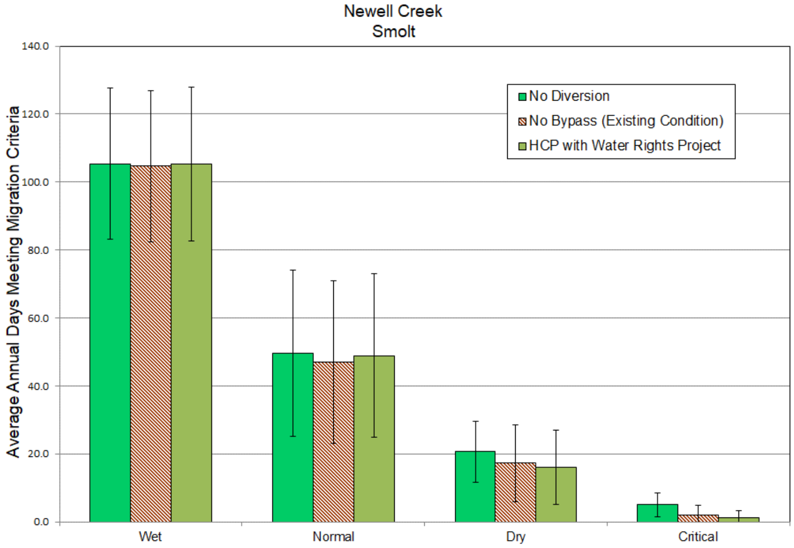


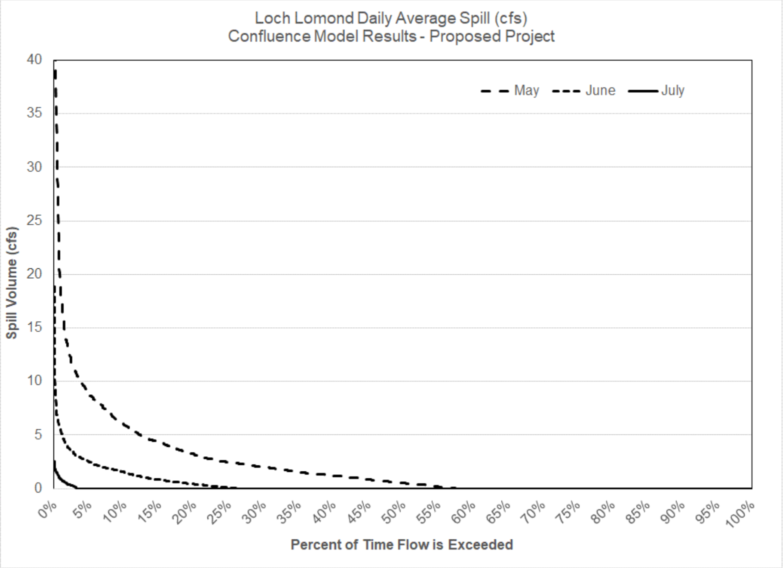
Table 5-6: Residual Effects of HCP Bypass Flows on Steelhead in Newell Creek

	Steelhead				
	Adult migration	**Spawning/incubation**	**Rearing-spring**	**Rearing-summer**	**Smolt migration**
Wet	0.0%	-0.6%	-4.8%	-4.4%	-0.2%
Normal	-2.4%	-1.9%	-6.7%	13.3%	-2.1%
Dry	-34.9%	-16.2%	-3.2%	26.6%	-23.3%
Critically dry	-88.7%	-33.6%	8.6%	33.0%	-80.0%

* Difference of 1 day or less

The effect of warm reservoir spills is moderated by the frequency, volume, and timing of spill. There is possible cooling at night (although potentially offset by additional warming during the day) as water flows down the spillway, and mixing with the cooler water from the fish release below the dam. Data collected by the City were evaluated to better understand the potential and magnitude of this effect. At times when the spill is warmest later in the spring, the amount of spill tends to be declining and it is diluted to a greater degree by the colder fish release. Daily spill volumes estimated by the Confluence model for the HCP using the historical hydrological record (1937-2015) indicate that spill would occur about 58% of the time in May, 27% of the time in June, and 3% of the time in July (Figure 5-17). Maximum spill amounts would be 77 cfs in May, 19 cfs in June, and 2.5 cfs in July. The model results predict two days in August during the entire record when spill would occur and a maximum spill of 0.20 cfs. No spill was predicted to occur in September, or October. The highest spill amount for May is a result of data from 1983, which was a very wet year, the second wettest in the hydrologic record. The reservoir was spilling continuously from mid-November 1982 and storms in late April resulted in increased spill through early May of up to 77 cfs. Spill declined to 15 cfs by mid-May and continued dropping until it ceased on August 2. It is likely that reservoir temperature was moderated during this period by cool air temperature and overcast conditions typical during storm passage. Late season storms, such as occurred in 1957, 1996, 1998, 1995, and 1941, were responsible for the majority of high spill events in May that are evident in the Confluence model results. Similar to the 1983 data, these events are likely associated with relatively cool reservoir temperatures. Absent late season storms in May, spill amount is rarely in excess of 16 cfs.

Figure 5-17: Loch Lomond Daily Average Spill from Confluence Model Results for the Proposed Project



The effect of warm spill from the reservoir is offset by cold water released through the fish release. In May, the warmest surface temperature in the City database for Loch Lomond surface temperature is 24.6°C. If 16 cfs is flowing over the spillway at that temperature, a simple mass/energy balance would predict that the resulting flow in Newell Creek downstream of the spillway would be 23.9°C after mixing with a flow of 1 cfs from the fish release at 12°C. Increasing the fish release to 6.5 cfs would result in a temperature of 21°C. An upgrade to the Newell Creek Dam outlet structure, currently under construction, will allow for significantly higher releases. During June, the Confluence model predicts much lower spill levels. The highest spill amount for June was modeled at 19 cfs but this was the result of a late season storm in the historic hydrologic record for 2011 representing a single day of the record. In all other model years, predicted spill in June was 10 cfs or less and only exceeded 5 cfs about 1% of the time. The amount of cold release to cool this level of spill to 21°C or less (~3 cfs), is well within the capacity of the fish release, even at the maximum observed June reservoir surface temperature of 26.3°C. For July, the maximum spill in the model results is 2.5 cfs but the maximum temperature in the City monitoring data is 26.9°C. Under these conditions a flow of 2 cfs through the fish release at 12°C would be sufficient to lower the resulting temperature to less than 21°C.

Increased frequency of spill in April and May with associated warmer temperatures may actually be beneficial for rearing steelhead (and coho if present) as long as the temperature is still within the suitable range. Salmonids grow faster at warmer temperatures within the suitable range with adequate food supply. Increased spill in June may also be beneficial as long as it does not result in temperature above the suitable level.

At times when the reservoir is spilling and the 1 cfs fish release is not sufficient to maintain temperature in Newell Creek below 21°C, Measure WS-24 requires the City to release additional flow through the fish release to achieve a maximum instantaneous temperature of less than 21°C as measured in the anadromous reach of Newell Creek and verified at the City stream gage in Newell Creek below the dam. With the implementation of this operational practice, potential adverse temperature effects in Newell Creek and the San Lorenzo River due to an increase in spill frequency would be avoided.

San Lorenzo River downstream of Felton

Operation of the Felton Diversion potentially influences about 7 miles of anadromous habitat down river to the Tait Street Diversion. Analysis of modeled flow data indicates that average annual migration potential is the same as it would be under a scenario with no City diversions (Figure 5-18). The analysis assumes that a flow of 40 cfs is the minimum required to meet passage criteria between the Felton Diversion and the Tait Street diversion (Section 4.4.2.1). The HCP bypass of 40 cfs provides 100% of the average number of migration days as with no City diversion at the Felton Diversion (Figure 5-18).

The analysis also used data from Ricker and Butler (1979) to assess the quality of spawning habitat provided for steelhead downstream of the Felton Diversion (Chapter 2). The HCP bypass flows result in small declines in normal, dry, and critically dry years, providing 100% of no-diversion levels in wet years, 99% in normal years, 97% in dry years, and 94% in critically dry years (Figure 5-19).

Based on the relationship between flow and WUA for rearing developed from the analysis of Ricker and Butler (1979) (see Chapter 2), HCP bypass flows provide at least 99% of the WUA index levels for rearing steelhead that would occur in the absence of City diversion (Figure 5-20).

Figure 5-18: Effects of Water Diversions on Adult Steelhead Migration in the San Lorenzo River Downstream of the Felton Diversion

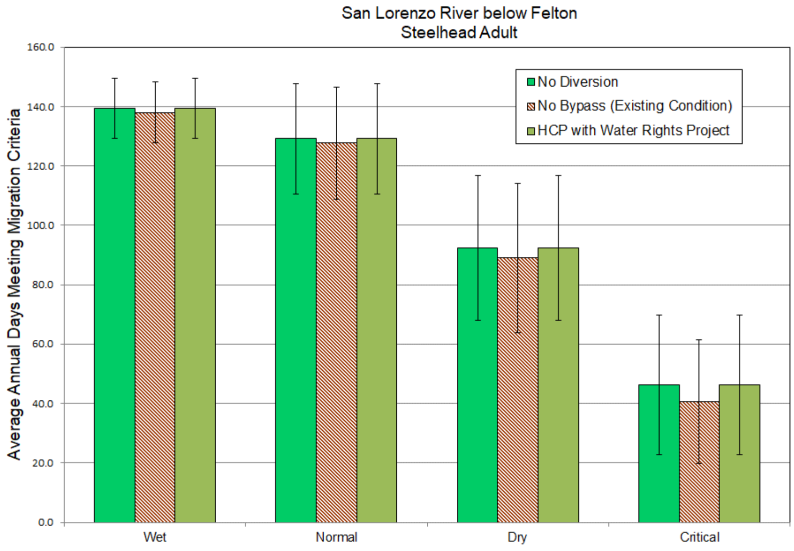
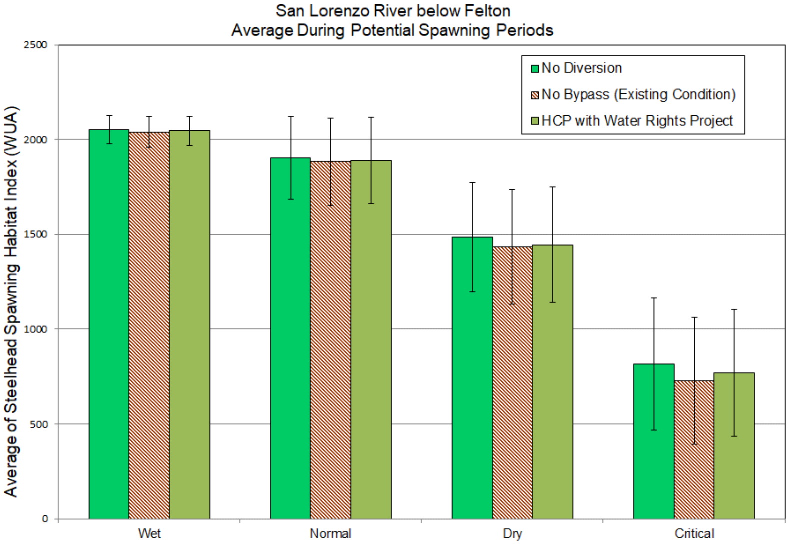


Figure 5-19: Effects of Water Diversions on Steelhead Spawning Habitat[53] in the San Lorenzo River Downstream of the Felton Diversion



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[53] Habitat is expressed as Weighted Useable Area in square feet per 100 feet.

Figure 5-20: Effects of Water Diversions on Steelhead Rearing Habitat in the San Lorenzo River Downstream of the Felton Diversion

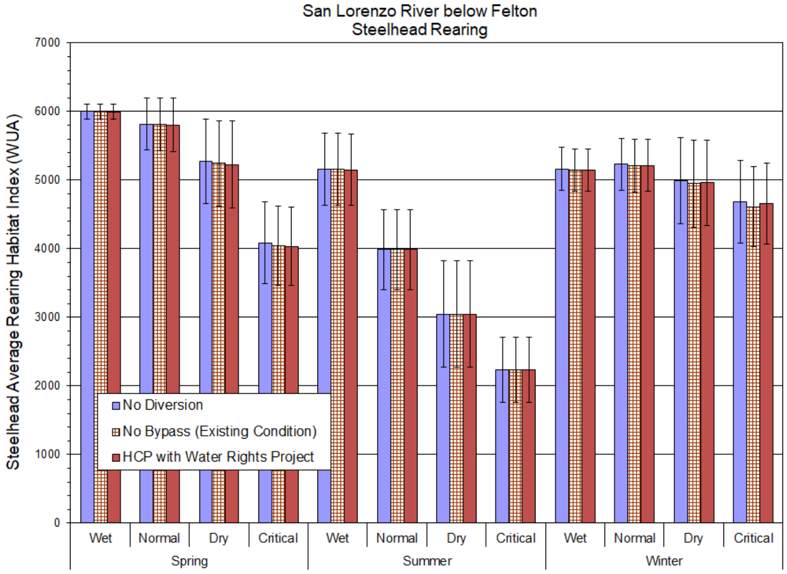
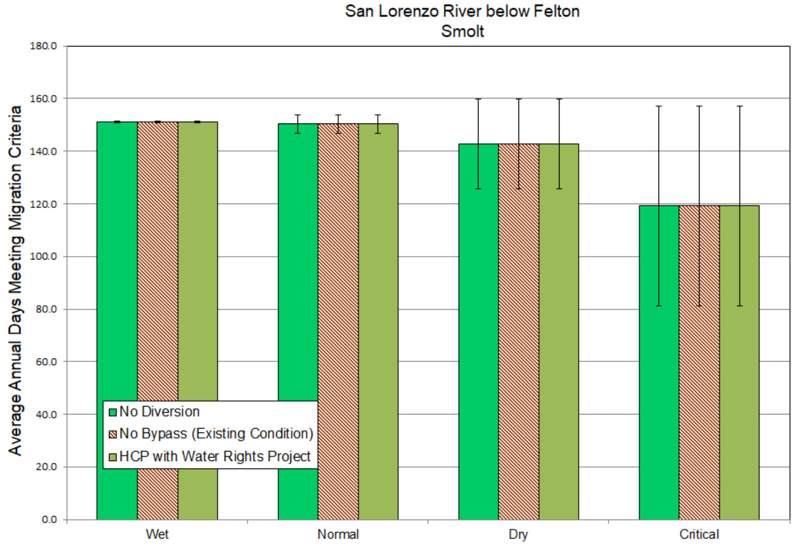


Figure 5-21: Effects of Water Diversions on Steelhead Smolt Migration in the San Lorenzo River Downstream of the Felton Diversion



To estimate the effect of flows on smolt migration, a minimum migration threshold of 20 cfs was used. While estimates for minimum migration flow for smolts in this reach are not available, there is evidence that smolts can migrate at flows at least as low as 26 cfs. During the summer of 2016, several smolt sized *O. mykiss* tagged in the lagoon in mid-June were observed at the Felton Diversion in July and August (HES 2017). The highest flow at Big Trees during that period was 26 cfs in mid-June. Flow declined to 11 cfs by late September so these fish migrated upstream at flows of no more than 26 cfs. Downstream migration would likely be easier and could presumably be accomplished at even lower flow. Comparison of minimum flows for smolt migration to minimum flows for adult migration from the other reaches yields an average estimate of smolt flows at 0.27 times the adult migration flow (Section 2.4.3.1). For the Felton reach this would yield an estimate of 11 cfs based on Berry's (2016) estimate for adult migration flows. The minimum threshold of 20 cfs used in this analysis is intermediate between the other two estimates. The HCP provides bypass flows during the smolt migration period that meet minimum migration criteria an average of 100% of the time that they would be met with no City diversions for both steelhead and coho (Figure 5-21).

The greatest residual effects for steelhead after implementation of HCP bypass flows downstream of the Felton Diversion are a 6% reduction in the spawning index in critically dry years and a 1% reduction in the rearing index in the spring of dry years (Table 5-7). The lower mainstem is important for rearing due to greater productivity and warmer water temperature resulting in greater growth rates of rearing juveniles (Chapter 2, Alley et al. 2004). The reach downstream of the Felton Diversion may also be important for spawning in drier years when access to the upper mainstem and tributaries may be difficult (Chris Berry, personal communication to Jeff Hagar, 2016.)

Table 5-7: Residual Effects of HCP Bypass Flows on Steelhead in San Lorenzo River Downstream of the Felton Diversion

	Steelhead			
	Adult migration	Spawning/ incubation	Rearing	Smolt migration
Wet	0.0%	-0.4%	-0.1%	0.0%
Normal	0.0%	-0.7%	-0.2%	0.0%
Dry	0.0%	-2.8%	-0.8%	0.0%
Critically dry	0.0%	-5.5%	-1.3%	0.0%

San Lorenzo River Downstream of Tait Street

The Tait Street Diversion influences up to 1.4 miles of riverine habitat, including 0.9 mile of FCC, depending on lagoon stage, and up to 1.5 miles of lagoon habitat. In the San Lorenzo River below Tait Street HCP bypass flows result in adult steelhead migration opportunities that are comparable to no-diversion levels in normal and wet years but somewhat less in critically dry years. Model results for operation of the Tait Street diversion indicate that the average number of days for suitable passage for steelhead are 100% of no-diversion levels in wet years, 99% in normal years, 97% in dry years, and 87% in critically dry years (Figure 5-22). These declines are comparable to existing conditions; however, there is still a significant amount of time when suitable passage flows exist in all year types. Even in critically dry years there is an average of over 100 days with conditions suitable for migration (Figure 5-23). In comparison, Laguna Creek in wet years, with no diversions, has less than 100 days available for migration (Figure 5-5).

Figure 5-22: Effects of Water Diversions on Adult Steelhead Migration in the San Lorenzo River below the Tait Street Diversion

The largest residual effects are 16% reductions in the rearing index in dry and normal years, is a 13% reduction in the number of days with suitable migration conditions for adults and a 8.5% reduction for smolts in critically dry years (Table 5-6).

The HCP bypass flows below Tait Street focus on improvements to rearing conditions and lagoon inflows. HCP flows, including the new minimum bypass of 8 cfs (60% of the maximum rearing index in this reach), significantly improve the rearing habitat index from existing conditions and provide a rearing index that is at least 84% of no-diversion levels in all year types (Figure 5-23). Improvements in rearing flows downstream of Tait Street also result in greater inflows to the San Lorenzo River Lagoon and potentially improve rearing conditions there as well.

Bypass flows under the HCP result in passage conditions for smolts that are nearly the same as no-diversion levels except in critically dry years. Suitable conditions for smolt migration occur on an average number of days that is 100% of no-diversion levels in wet and normal years, 98% in dry years, and 91% in critically dry years (Figure 5-24). The greatest residual effect is a reduction in the number of days with suitable passage conditions for smolts from 151 days to 138 days (9%) during the January to May smolt migration season in critically dry years (Table 5-8).

The San Lorenzo River Lagoon provides very important rearing habitat for steelhead. During the summer and particularly in low flow years when the lagoon closes for greater amounts of time, habitat conditions can become too warm for juvenile steelhead and oxygen levels can drop to unsuitable levels. Flow into the lagoon from the San Lorenzo River may benefit rearing habitat in the lagoon by refreshing the warm, deoxygenated, saline lens that can develop in the deeper waters of the lagoon. Inflows of fresh water from the San Lorenzo River may help maintain cooler temperatures throughout the water column and increase DO levels. Under existing operations there is no requirement to bypass flow at the Tait Street Diversion to the lagoon. The HCP imposes a minimum bypass of 8 cfs at the Tait Street Diversion under dry and very dry hydrologic conditions and higher bypass in wetter years. As a result, inflow to the lagoon is greatly improved in critically dry years and some dry years (Figure 5-25). The HCP bypass flows result in an average increase in summer inflow of 17% in normal years, 102% in dry years, and 963% in critically dry years relative to existing conditions. Average summer inflow with HCP bypass flows is 66% of no-diversion levels in wet years, 59% in normal years, 58% in dry years, and 77% in critically dry years (Figure 5-25). The largest residual effect of the Tait Street diversion on lagoon inflows is an average reduction of 42% in dry years compared to no-diversion levels.

Figure 5-23: Effects of Water Diversions on Steelhead Rearing Habitat in the San Lorenzo River below the Tait Street Diversion

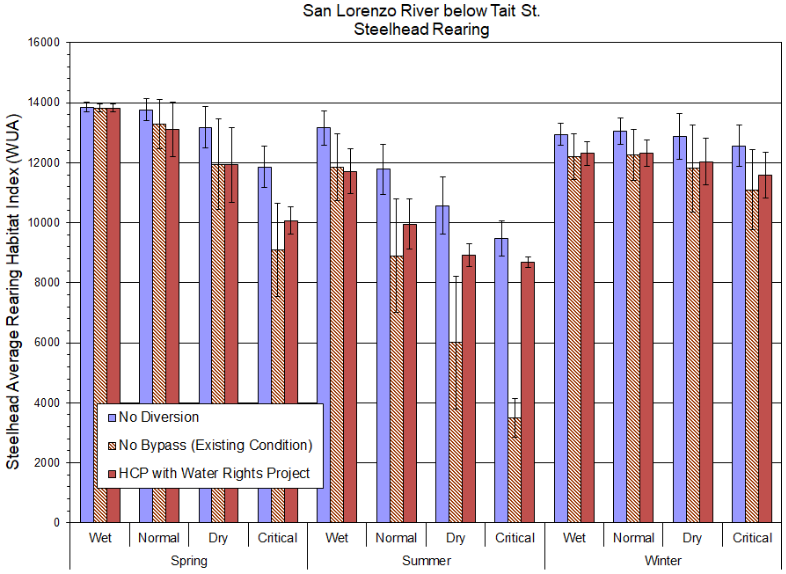


Figure 5-24: Effects of Water Diversions on Steelhead Smolt Migration in the San Lorenzo River below the Tait Street Diversion

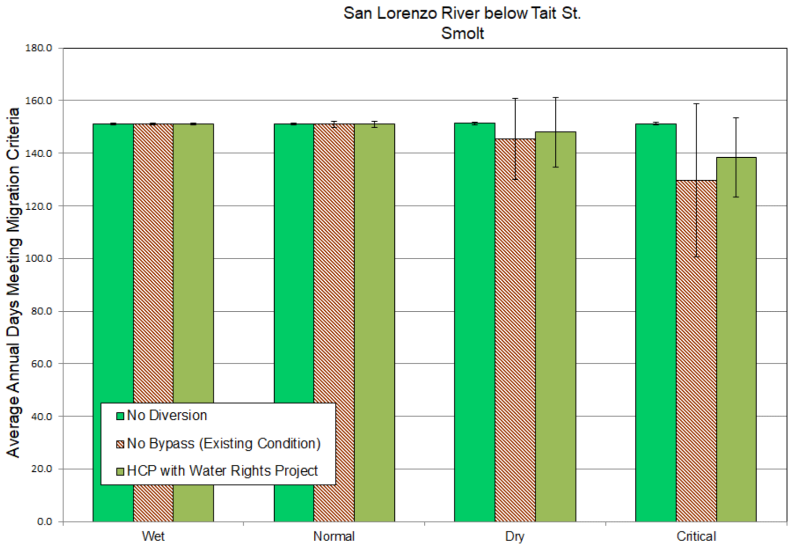


Figure 5-25: Effects of Water Diversions on Inflow to the San Lorenzo River Lagoon

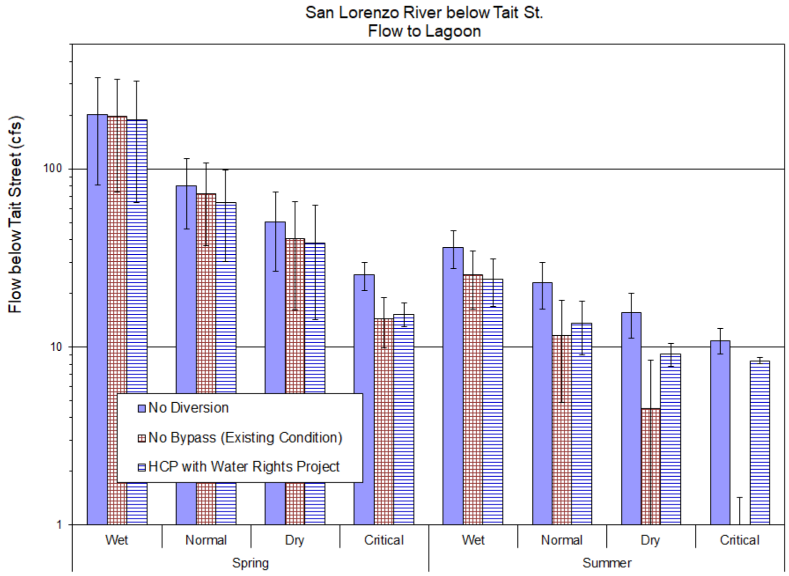


Table 5-8: Residual Effects of HCP Bypass Flows on Steelhead in the San Lorenzo River Downstream of Tait Street

	Steelhead			
	Adult migration	**Spawning / incubation**	**Rearing**	**Smolt migration**
Wet	-*		-11.0%	*
Normal	-*		-15.6%	*
Dry	-2.7%		-15.7%	-2.3%
Critically dry	-12.8%		-15.1%	-8.5%

* Difference of 1 day or less

5.2.1.1 Consideration of Climate Change Scenarios

The preceding analysis is based on the assumption of climate conditions that are consistent with the period of hydrologic record that has been observed since 1936. However, climate scientists are projecting shifts in climatic conditions as a result of increasing concentrations of carbon dioxide and other gasses released into the Earth's atmosphere. These shifts have the potential to influence climate parameters such as temperature and precipitation at the regional level, potentially altering streamflow regimes and habitat conditions for the Covered Species. As part of development of the HCP, as well as for water supply planning purposes, the City developed local hydrologic projections for climate change conditions based on global climate models developed by others (Chartrand 2018).

Climatic extremes of year-to-year and month-to-month precipitation variability is a hallmark of California's physical setting, and climate scientists expect variability observed in the historical record to become more pronounced in the future. On top of this, average and maximum air temperatures are expected to rise significantly across the State (Chartrand 2018). Higher average and maximum air temperatures will increase the frequency and occurrence of fire and increase water supply demand curves as use and consumption generally increase with temperature (Chartrand 2018). Changes in precipitation patterns and fire frequency and severity can also alter vegetation communities and hydrologic processes relating to channel form, thus also potentially impacting steelhead habitat.

The precise nature of future climate conditions is unknown and cannot be predicted with any degree of certainty. Temperature regimes in the Plan Area are already in the upper range of steelhead tolerance. Increasing temperatures may therefore result in population declines in the Plan Area. This is particularly true for the San Lorenzo River Lagoon, which likely produces the majority of steelhead in the San Lorenzo River system. NMFS determined that climate change will result in a variety of challenges for steelhead, including climate related threats which would increase vulnerability of steelhead in the San Lorenzo River and result in a 19.6 percent increase in the threat ranking (NMFS 2016b). The north coast streams and Laguna Creek Lagoon are cooler and steelhead populations in those streams may be more buffered from the effects of a warming climate. In addition, climate models used in Chartrand's analysis do not include the effects of the summer marine layer that substantially moderate temperature in these streams (S. Chartrand, personal communication, 3/23/2019).

More pronounced variability in precipitation patterns could result in more extreme dry years or longer drought periods and more damaging flood flows in wet years. Neither extreme is beneficial for steelhead populations, although steelhead have flexible life-history patterns that make them very adaptable to variable weather conditions, which they experience to some degree in the Plan Area at present. Under extreme climate change scenarios, it is possible that the range of steelhead will shrink into smaller core areas in the north Pacific basin. Although there are still steelhead populations south of the Plan Area (their range in the past has extended into Baja California), these populations are small and have limited productive capacity. Many species experience range expansions and contractions along the edges of their distributions in response to changing environmental parameters, and the Plan Area is near the edge of present-day steelhead distribution. As a result, during the duration of the Plan it is possible that the range of steelhead will contract in the face of changing climatic conditions despite measures in the conservation strategy designed to increase steelhead abundance.

5.2.2 Coho

Potential habitat for coho is limited to the San Lorenzo River watershed and possibly Laguna Creek. This section describes the effects to coho resulting from the proposed bypass flows at the City's diversions. Hydrologic model results were evaluated for effects on each life stage of coho below each applicable City diversion.

Laguna Creek

Habitat exists for coho in Laguna Creek and all life stages are potentially supported in the 1.4 miles of anadromous habitat. Habitat effects for coho are substantially avoided in Laguna Creek by providing bypass flows that result in habitat index values that are close to levels that would occur with no City diversions. The adult migration index under HCP flows is changed by less than 1 day annually on average compared with No Diversions (Figure 5-26). Similarly, there is minimal change in the spawning habitat index with the HCP spawning index at least 98% of the level with No-Diversion (Figure 5-27). The rearing habitat index for coho in Laguna Creek equals or slightly exceeds no-diversion levels (Figure 5-28). Coho have a preference for lower velocities than steelhead and diversions during the highest flow periods can actually improve the index. The smolt migration index is also greatly improved from existing conditions and averages at least 98% of no-diversion levels in all year types (Figure 5-29) with less than 1 day reduction on average in any year type. Habitat index values represent significant improvement relative to the Existing Condition. The effects of the Laguna Creek Diversion on coho are fully avoided and there are no residual effects (Table 5-9).

Figure 5-26: Effects of Water Diversions on Coho Adult Migration in Laguna Creek

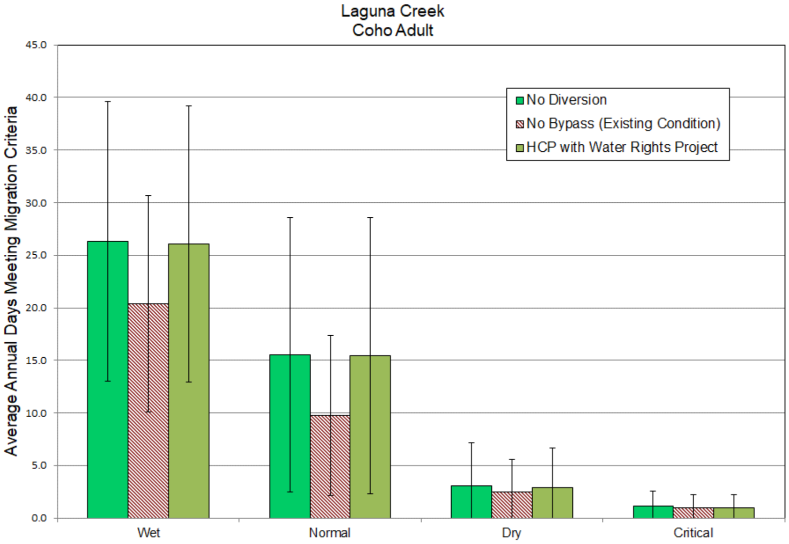


Figure 5-27: Effects of Water Diversions on Coho Spawning Habitat in Laguna Creek

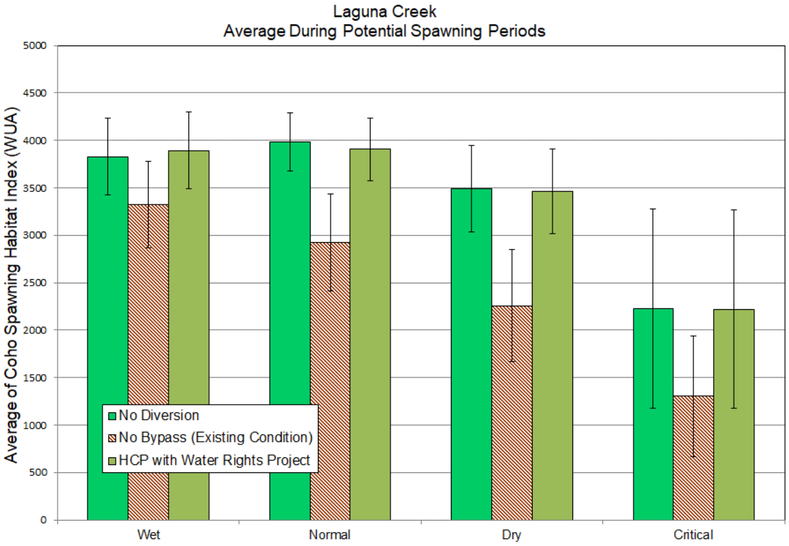


Figure 5-28: Effects of Water Diversions on Coho Rearing Habitat in Laguna Creek

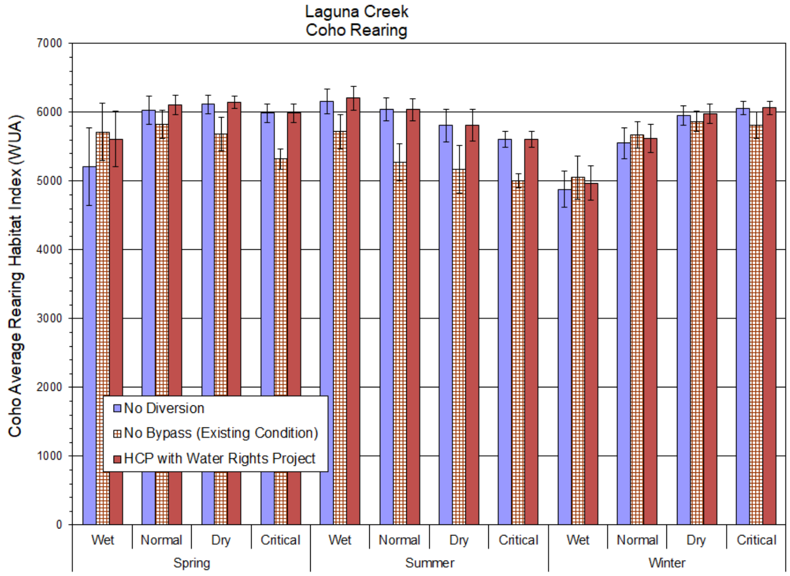


Figure 5-29: Effects of Water Diversions on Coho Smolt Migration in Laguna Creek

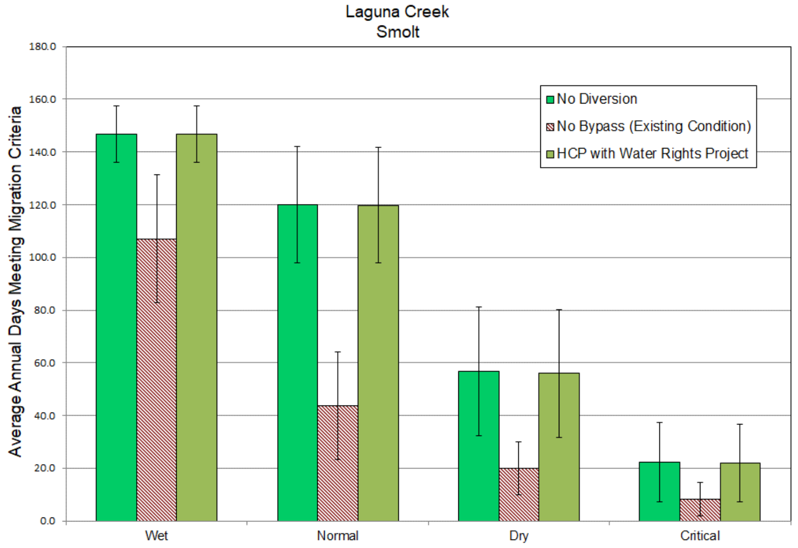


Table 5-9: Residual Effects of HCP Bypass Flows on Coho in Laguna Creek

	Coho			
	Adult migration	**Spawning/ incubation**	**Rearing**	**Smolt migration**
Wet	*	1.6%	0.6%	*
Normal	*	-2.0%	-0.1%	*
Dry	*	-0.8%	0.0%	*
Critically dry	*	-0.3%	0.0%	*

* Difference of 1 day or less

Newell Creek

As described previously for steelhead, implementation of HCP bypass flows results in somewhat greater fluctuation in storage in Loch Lomond Reservoir with higher storage and slightly greater spill frequency in wetter years and lower frequency and duration of reservoir spill in drier years, influencing about 1 mile of anadromous habitat in Newell Creek downstream of Newell Creek

Dam. Frequency of flows sufficient for adult coho migration are reduced compared to no-diversion levels by 2 to 4 days on average corresponding to changes of 5 % (3.6 days) in wet years, 10 % (3 days) in normal years, 44% in dry years (from 3.5 days to 1.2 days), and 100% (from 2 days to 0 days) in critically dry years (Figure 5-30). The spawning habitat index is increased slightly in wet years (+1.0%) and normal years (+0.6%), but decreases 15% in dry years, and 36% in critically dry years (Figure 5-31). Coho are more affected than steelhead by reduced spills from Loch Lomond Reservoir because they migrate and spawn early in the winter, while the reservoir is more likely to spill in the late winter after more runoff has accumulated.

Habitat conditions for rearing coho have relatively high index values at all times as a result of juvenile coho preference for lower velocities. The lowest index values occur in wet winters when flow velocity is greatest (Figure 5-32). There is some benefit from the 1 cfs minimum release during drier summers under both existing conditions and HCP flows. Overall, the HCP flows have beneficial effects on coho rearing habitat in Newell Creek and beneficial residual effects.

Habitat conditions for smolt migration are the same as for steelhead since both migrate during the same time period. Flows suitable for smolt migration are reduced by 2 to 7 days from no-diversion levels (Figure 5-33). The greatest reductions in percentage terms are in dry years (23% reduction from 21 days to 13.5 on average) and critically dry years when the average number of days with suitable migration conditions is reduced from 5 days with no diversions to 1 day with HCP flows, an 80% reduction.

The greatest residual effects, in terms of percentage change for coho in Newell Creek are the reductions in adult migration and spawning indices in critically dry years of up to 100 % for migration and 36 % for spawning; the increase in rearing index in summer and critically dry springs; and reduction in the average smolt migration index of up to 80% in critically dry years (Table 5-10). The migration and spawning effects are not likely to be biologically significant since they involve a relatively small magnitude of actual habitat change and very low habitat values even with no diversions. In the case of adult migration, the change in the actual number of days with suitable migration conditions averages between 3.6 days in wet years to 1.9 days in critically dry years. For smolt migration, the maximum change in percentage terms of 80% in critically dry years corresponds with a potential migration index of only 5 days based on No-Diversion levels during the 150-day potential migration period. The 30% reduction in the spawning habitat index in critically dry years is also not likely to be biologically significant since the habitat indices are quite low even without the reservoir (No Diversion).

Figure 5-30: Effects of Water Diversions on Coho Adult Migration in Newell Creek

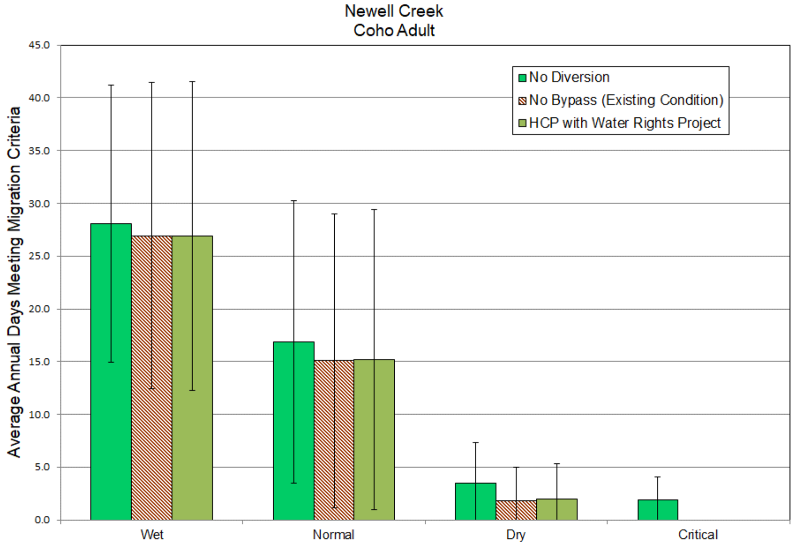


Figure 5-31: Effects of Water Diversions on Coho Spawning Habitat in Newell Creek

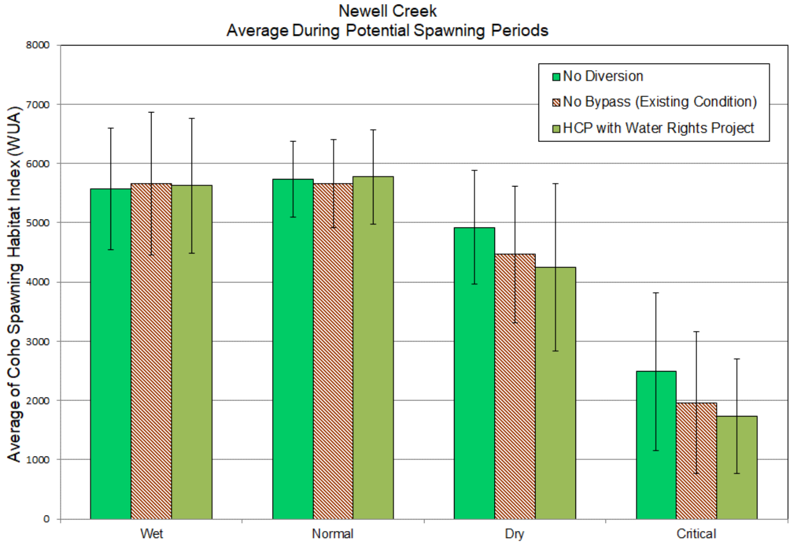


Figure 5-32: Effects of Water Diversions on Coho Rearing Habitat in Newell Creek

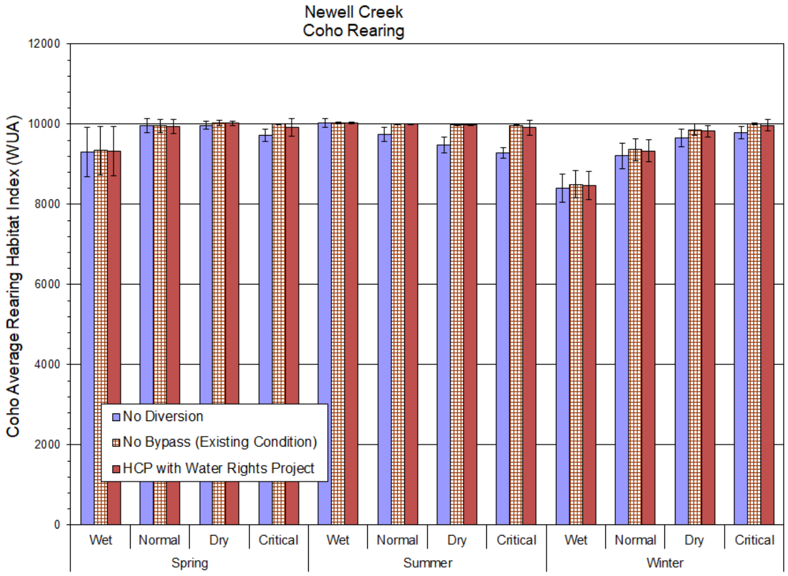


Figure 5-33: Effects of Water Diversions on Coho Smolt Migration in Newell

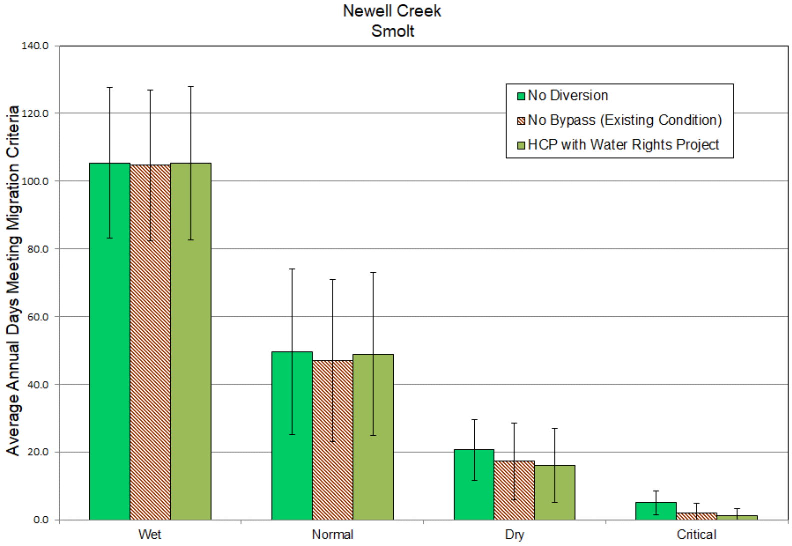


Table 5-10: Residual Effects of HCP Bypass Flows on Coho in Newell Creek

	Coho				
	Adult migration	Spawning/ incubation	Rearing-spring	Rearing-summer	Smolt migration
Wet	-5.2%	1.0%	0.3%	0.0%	-0.2%
Normal	-10.0%	0.6%	-0.1%	2.7%	-2.1%
Dry	-44.2%	-14.9%	0.5%	5.3%	-23.3%
Critically dry	-100.0%	-36.0%	2.0%	6.8%	-80.0%

San Lorenzo River Downstream of the Felton Diversion

Coho potentially use the San Lorenzo River mainstem downstream of the Felton Diversion for adult and smolt migration. It is expected that, due primarily to temperature considerations, the majority of potential spawning and rearing habitat for coho is in the tributaries and upper mainstem. As was the case for steelhead, and assuming a flow of 40 cfs or more is required for adult migration (Section 4.4.2.1), average annual migration potential for coho is the same as what it would be with no City diversions (Figure 5-34). The HCP bypass of 40 cfs provides 100% of the average number of migration days for coho below the Felton Diversion as with no City diversion. A 20 cfs minimum migration flow was used for the smolt evaluation (see discussion under steelhead effects downstream of the Felton Diversion). The HCP provides bypass flows that meet minimum migration criteria for coho smolts 100 % of the time that they are met with no City diversions (Figure 5-35).

Based on these analyses, there are no residual effects of the HCP bypass flows on coho downstream of the Felton Diversion (Table 5-11).

Figure 5-34: Effects of Water Diversions on Coho Adult Migration in the San Lorenzo River below the Felton Diversion

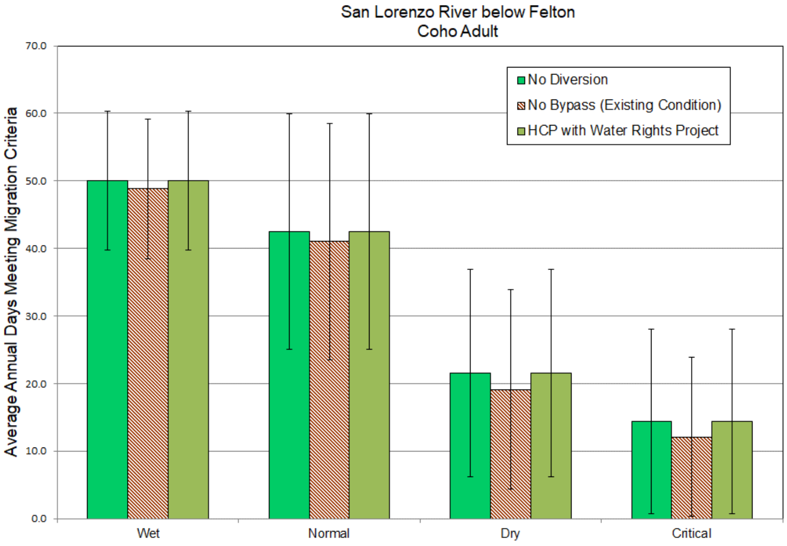


Figure 5-35: Effects of Water Diversions on Coho Smolt Migration in the San Lorenzo River Downstream of the Felton Diversion

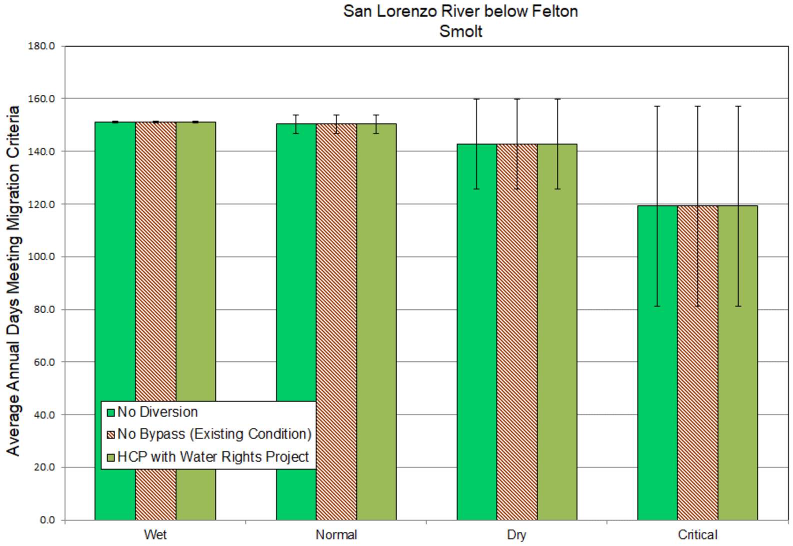


Table 5-11: Residual Effects of HCP Bypass Flows on Coho in the San Lorenzo River Downstream of the Felton Diversion

	Coho			
	Adult migration	**Spawning/ incubation**	**Rearing**	**Smolt migration**
Wet	0.0%			0.0%
Normal	0.0%			0.0%
Dry	0.0%			0.0%
Critically dry	0.0%			0.0%

<u>San Lorenzo River Downstream of Tait Street</u>

Coho potentially use the San Lorenzo River mainstem below the Tait Street Diversion for adult and smolt migration. There is no spawning habitat for coho in this reach and temperature and other habitat conditions are not suitable for rearing. Unlike steelhead, coho do not appear to use estuaries for rearing in this part of their range (Section 2.5.2). The effect of the Tait Street diversion on coho adult migration is very similar to the effects on steelhead. There are no declines in adult migration periods of more than 1 day in wet, normal, or dry years compared to no-diversion levels. In critically dry years, adult migration periods average 9.8% less than no-diversion levels. HCP bypass flows result in an average number of days with suitable migration conditions for coho that is 100% of no-diversion levels in wet years, 98 % in normal years and dry years, and 90% in critically dry years (Figure 5-36). As for steelhead, the critically dry year reductions in the migration index may not have a biologically significant effect since there are still a significant amount of migration opportunities. There are an average of 45 days when migration conditions are suitable out of the 60 possible during the December-January migration period for coho in critically dry years.

The residual effect on smolt migration is the same as that for steelhead since both species migrate at the same time. Bypass flows under the HCP result in passage conditions for smolts that are nearly the same as no-diversion levels except in critically dry years when they occur at 91% of no-diversion levels, a reduction from 151 days with suitable conditions to 138 days (Figure 5-37).

Maximum residual effects of the HCP flows on coho habitat downstream of Tait Street include a reduction in the number of days with suitable conditions for adult migration of 20% in critically dry years and a maximum reduction of 8.5% in the index for smolt migration, also in critically dry years (Table 5-12).

Figure 5-36: Effects of Water Diversions on Coho Adult Migration in the San Lorenzo River below Tait Street

Figure 5-37: Effects of Water Diversions on Coho Smolt Migration in the San Lorenzo River below Tait Street

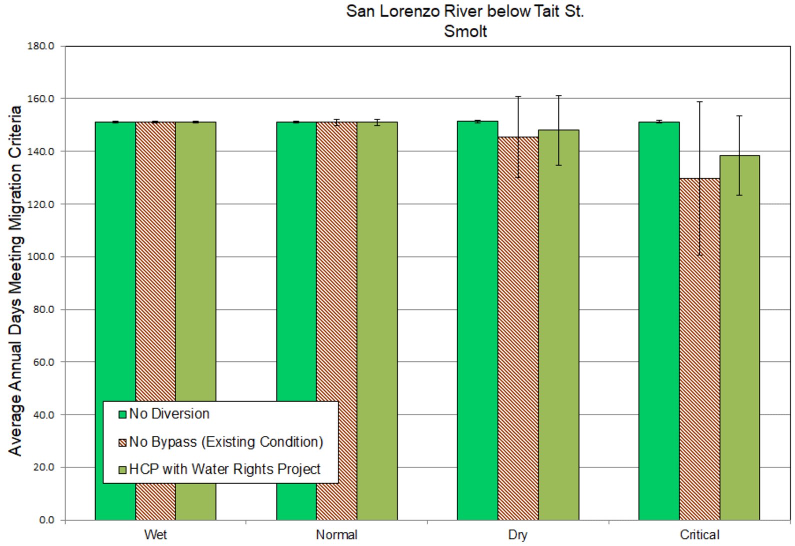


Table 5-12: Residual Effects of HCP Bypass Flows on Coho in the San Lorenzo River Downstream of Tait Street

	Coho			
	Adult migration	**Spawning/ incubation**	**Rearing**	**Smolt migration**
Wet	*			*
Normal	*			*
Dry	*			-2.3%
Critically dry	-9.8%			-8.5%

* Difference of 1 day or less

5.2.2.1 Consideration of Climate Change Scenarios

Coho have been rated as “critically vulnerable” to the effects of climate change. Unlike steelhead, coho have a relatively fixed life-history pattern with an approximate 1.5-year freshwater rearing period and a 1.5-year ocean maturation period. This means that weakness in any year-class cascades from generation to generation and weak year-classes are not readily rebuilt. Coho lack the diversity in life-history strategies characteristic of steelhead and do not do as well with excessive variability in environmental conditions. In that sense, they are less adaptable and will have more difficulty adapting to changing climatic conditions that are projected for the Plan Area under various climate change scenarios. Increasing air temperatures have the potential to limit the quality and availability of summer rearing habitat for juvenile coho by increasing water temperatures. Increases in fall and winter temperature regimes might shorten incubation and emergence times for developing eggs, which has been predicted to lead to lower survival rates. Increases in summer temperatures will lead to thermal stress, decreased growth and affect survival of out-migrating juveniles (NMFS 2012b).

In addition, coho spawning activity is concentrated early in the wet season (primarily in December and January). This makes their redds and fry vulnerable to damage from storms during the peak runoff months of February and March that follow. The possibility of more extreme flooding under climate change scenarios modeled for the region suggests that it will be difficult to reestablish coho populations in the Plan Area. In analyzing the rangewide data for coho, NMFS determined the San Lorenzo River population of coho to be at a high or very high risk of threat from climate change (NMFS 2012b).

The Plan Area is at the southern end of the coho range. Coho have lower thermal tolerance and preferences than steelhead and any increase from present levels could be problematic for coho. In fact, existing variability in hydrologic patterns and peak storm flows, combined with warmer thermal regimes that have developed to date may in large part explain the absence of coho from the Plan Area at the present time, and may severely limit the potential for their re-establishment and recovery in the Plan Area despite the efforts of the City, as set forth in the conservation strategy, and conservation efforts of the fishery agencies and other conservation partners.

5.3 Effects of Water System Operation and Maintenance

The majority of potential effects from this activity are avoided by application of BMPs and SOPs already incorporated in Covered Activities (Section 4.4). The exception is the incidental take associated with capturing and relocating Covered Species from work areas when instream work is conducted. The level of effect is dependent on the frequency of projects requiring instream work, the location and areal extent of the projects, and the numbers of Covered Species present in the work area that need to be relocated. Activities that may generate the need to relocate Covered Species include repair and maintenance of diversion facilities; sediment management; fish ladder and fish screen maintenance and repair; and pipeline operations and maintenance.

Sediment removal is occasionally necessary at the Laguna Creek and Majors Creek diversions; however, both diversions are located well upstream of the limit of anadromy and would not require relocation of Covered Species. Maintenance or repair of fish screens and ladders at the Felton Diversion and the Tait Street Diversion as well as planned rehabilitation of fish screens at both fish facilities may require dewatering and relocation of Covered Species. It is likely that this activity would only occur once or twice at each facility during the life of the HCP. A limited length of stream would be affected, probably not more than 300 feet. Effects of relocation may include temporary interruption in feeding activity, increased exposure to predation, traumatic injury, and mortality. These effects can be minimized by protective measures (Section 4.4.3.4).

5.3.1 Steelhead

Based on rearing juvenile steelhead surveys in the San Lorenzo River, rearing densities of juvenile steelhead might range from 4 to71 juveniles per 100 feet of stream at the time work is performed (based on annual abundance measured at SL-main-4 between 2007 and 2018, Santa Cruz County Environmental Health Steelhead Monitoring Data[54]). Assuming an average density of 50 steelhead per 100 feet of stream and total length of stream affected of 1,200 feet (300 feet per event, two events at each facility over the term of the permit), a total of 600 steelhead may be relocated. Relocations conducted by professional biologists using protective measures typically result in direct mortality due to handling stress and incidental mortality that is less than 3%, or 18 fish out of 600.

5.3.1 Coho

No coho have been observed in the mainstem San Lorenzo River downstream of the Felton Diversion in annual juvenile salmonid surveys in recent years and even if coho become re-established in the San Lorenzo River they are more likely to be found rearing in the tributaries. Based on current low abundance of coho, no coho are expected to be relocated. If coho become re-established, relocation efforts may affect a small number of individuals. Relocations

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[54] http://scceh.com/steelhead/data.aspx

conducted by professional biologists using protective measures typically results in direct mortality that is less than 3%.

5.4 Effects of Municipal Facility Operation and Maintenance

The majority of potential effects from this activity are avoided by BMPs and SOPs incorporated into the Covered Activities (Section 4.4). Potential residual effects are related to sediment removal activities conducted in the San Lorenzo and Branciforte FCCs. This activity could involve dewatering sections of the FCCs and relocation of Covered Species. Effects are described in the following Section and summarized in Table 5-1 (steelhead) and Table 5-2 (coho).

5.4.1 Steelhead

This activity has been conducted infrequently in the past and would be expected to be infrequent during the term of the HCP, perhaps as often as three times in the San Lorenzo FCC and every five years in the Branciforte FCC. Densities of rearing juvenile steelhead are variable. The San Lorenzo River FCC supports reasonably good rearing habitat for juvenile steelhead. Recent surveys have documented abundances ranging from 2 to 27 steelhead per 100 feet of stream in 11 annual surveys between 2000 and 2018[55] (Santa Cruz County Environmental Health Steelhead Monitoring Data[56]). Sediment removal in the San Lorenzo FCC is generally conducted by removing sediment from outside the wetted channel, leaving a narrow buffer and it is expected to be conducted this way in the future (Chris Berry, personal communication, 3-26-2019).

The Branciforte Creek FCC was characterized in three reaches with different habitat conditions during a survey in 2003 (HES 2003b). The upper portion of FCC (about 1,900 feet) was relatively high gradient with little sediment accumulation. It is a concrete box culvert with dry-season flows largely confined to a small, central, trapezoidal low-flow channel with a top width of 3 feet and depth of about a foot that provides minimal habitat for Covered Species. The middle section, from about Water Street to about Ocean Street, was lower gradient and had accumulations of sediments up to gravel size that formed bars with some colonization by vegetation. The lower part of the Branciforte FCC, downstream of Ocean Street, had a thin layer of sand accumulation but no vegetation. The lower and middle portions of the FCC comprised

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[55] Survey results for Station SLR-main-0a (between Highway 1 and the pedestrian bridge).
[56] http://scceh.com/steelhead/data.aspx

about 3,100 feet. The lower end of the FCC may be inundated by the lagoon at higher lagoon stages. Four juvenile steelhead were captured in a 193-foot section of the uppermost portion, but none were captured in the middle section and none were seen in visual surveys of the lower section (HES 2003b). The population density in the upper portion would be estimated at 2 steelhead per 100 feet of FCC. If it is assumed that sediment removal is conducted three times over the term of the HCP for the 3,100-foot lower and middle portions where sediment accumulates and that density of rearing juvenile steelhead is comparable to the upper section encountered in 2003, then up to 62 juvenile steelhead may be relocated during each sediment removal episode with direct mortality of 2 juvenile steelhead.

5.4.1 Coho

The San Lorenzo and Branciforte FCCs do not provide suitable habitat for coho and juvenile coho are not expected to be found there. Therefore, this activity is unlikely to have any effect on coho.

5.5 Effects of Land Management

The majority of effects related to Covered Activities in this category are avoided through application of BMPs and SOPs (Chapter 4). Aquatic habitat management has the potential for residual effects if Covered Species need to be relocated during construction of instream habitat improvement projects. The species and numbers affected will depend on the location and areal extent of the projects. It is assumed that up to 30 locations may be affected over the term of the HCP and that the average areal extent will involve 300 feet of stream channel that requires dewatering. Effects are described below and summarized in Table 5-1 (steelhead) and Table 5-2 (coho).

5.5.1 Steelhead

Average density of rearing juvenile steelhead is assumed to be 50 per 100 feet of stream. Over the term of the HCP up to 4,500 juvenile steelhead may need to be relocated and there may be direct mortality of up to 135 juvenile steelhead.

5.5.1 Coho

Some of these activities could occur in the tributaries where rearing coho may be present. Average densities are expected to be very low in the near term, but effects could occur if coho become re-established in the Plan Area. Under such future conditions coho may be found at up to one-third of the project locations, likely at densities not more than half those of rearing steelhead. Therefore, it is possible that, under these assumptions, as many as 750 coho may need to be relocated over the term of the HCP and there may be direct mortality of up to 23 juvenile coho.

5.6 Effects of the HCP Monitoring Program

The HCP monitoring program is described in detail in Chapter 6. Effects of the monitoring program are described in detail in the following Section and summarized in Table 5-1 (steelhead) and Table 5-2 (coho).

5.6.1 Steelhead

Three elements of the monitoring program have the potential to affect steelhead: juvenile abundance monitoring in riverine reaches, juvenile abundance monitoring in lagoons, and adult abundance at the Felton Diversion.

Juvenile abundance monitoring involves near-term continuation of existing snorkel surveys in the initial 3-year term of the HCP. Snorkel surveys involve direct observation of Covered Species in pools in the anadromous reaches of each of the north coast streams. Potential effects include disturbance, temporary dislocation from preferred habitats, and interruption of normal behaviors, including feeding. Numbers observed, based on past surveys, is expected to be on the order of 1,500 juvenile steelhead, 5 adult steelhead, and 100 juvenile coho.

Juvenile abundance monitoring may involve electrofishing surveys using mark-recapture estimates with PIT tagging in portions of the San Lorenzo River (Chapter 6). This monitoring element is intended to be consistent with the CMP which is still under development. The City monitoring program may change in response to evolution of the CMP. Any changes will be addressed through the TAC. The following assessment uses hypothetical assumptions for electrofishing to represent a “most likely” effects assessment.

Eight sample reaches will be selected each year and each reach will be sampled twice: once for marking, once for recapture. Sampled lengths will be on the order of 300 to 500 feet per sample reach or up to 4,000 feet total annually. Assuming average density of 50 steelhead per 100 feet of stream based on the Santa Cruz County monitoring data[57] a total of up to 2,000 juvenile steelhead may be captured with incidental mortality of up to 60 individuals.

Juvenile abundance monitoring in lagoons involves capture with large seine nets with tagging and release. The San Lorenzo River Lagoon is sampled monthly between June and October and Laguna Creek Lagoon is sampled once in June and September. Past surveys since 2007 have resulted in capture of up to 12,000 steelhead in a season in the San Lorenzo River Lagoon and up to 700 steelhead in the Laguna Creek Lagoon. Incidental mortality may be as high as 2% or as many as 240 in the San Lorenzo and 14 in Laguna Creek.

Monitoring of adult abundance at the Felton Diversion involves capture in a trap installed in the fish ladder, holding, examination, tagging, and release by the Monterey Bay Salmon and Trout Project (MBSTP - a local fisheries conservation hatchery volunteer organization). This work is currently covered by permits between DFW, NMFS, and MBSTP. Past operation of the Felton Diversion trap (through 2013) has resulted in capture of as many as an estimated 3,000 steelhead (Alley 2015). This would likely be the maximum number of adult steelhead affected by the trapping operation in the future. There have been isolated events of MBSTP permit non-compliance that have resulted in mortality of adult steelhead in the past. It is anticipated that future monitoring overseen by the City would have a greater level of regulatory oversight than was historically the case with MBSTP. Subsequently, it is expected that there will be lower risk of mortality with future trapping operations.

5.6.1 Coho

The HCP monitoring program is described in detail in Chapter 6. The three elements of the monitoring program that have the potential to affect coho are juvenile abundance-riverine, juvenile abundance-lagoons, and adult abundance at the Felton Diversion. Juvenile abundance based on snorkel surveys has the potential to effect up to 100 juvenile coho based on the results of past surveys conducted by the City in the north coast streams. Juvenile abundance monitoring involving electrofishing has the potential to affect coho if they become re-established in the San Lorenzo River and Laguna Creek. In that case, they may occur in half the eight sample reaches, primarily in San Lorenzo River tributaries. Assuming they would occur at a density of 25 per 100 feet of stream, about half the density of steelhead, it is estimated that up to 500 coho may be captured each year with incidental mortality of 15 individuals.

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[57] http://scceh.com/steelhead/data.aspx

Coho do not appear to use lagoon habitat for rearing as steelhead do and are less likely to be captured in lagoon monitoring surveys. In annual surveys from 2004 to present coho have been captured in only one year in Laguna Creek and never in the San Lorenzo River Lagoon. That could change if coho become re-established in the Plan Area. Based on past surveys it is possible that up to 200 coho might be captured in a season in both lagoons with incidental mortality as high as 4 individuals.

Upstream migrating coho have been trapped at the Felton Diversion by the Monterey Bay Salmon and Trout Project and peaked at 183 adults in 1989-1990 (Brown et al. 1994); however, in most years, few coho were captured (ENTRIX, Inc. 2004). A few coho have occasionally been observed in the trap since that time, with the most recent in the winter of 2012-2013 (Alley 2015). It is expected that few coho will be encountered in the adult monitoring trap at the Felton Diversion, likely less than 10 per year. If coho become re-established in the San Lorenzo River, numbers would increase but would not be likely to exceed 200 adults in a season.

6.0 PLAN IMPLEMENTATION

6.1 Introduction

This chapter identifies the issues that are related to Plan implementation and the approaches that will be used to address those issues over the term of the Plan. The chapter describes requirements for short-term and long-range planning, and budgets, monitoring, and compliance reporting. The chapter further describes the regulatory assurances under the ESA that are expected to be provided to the City. It also describes the commitment of the City to respond to foreseeable changes in circumstances that may adversely affect Covered Species and habitats and identifies a process by which changes that are not foreseeable can be addressed. The chapter also identifies the circumstances under which regulatory authorizations may be suspended or revoked.

6.2 Role of the City

6.2.1 Process for Water Supply Reliability

In 2014, the City Council convened the WSAC to engage a multi-disciplinary, stakeholder-driven process that would advise the Council on future water supply development. The overarching goal of the Committee’s effort is to provide significant improvement to the sufficiency and reliability of the Santa Cruz water supply by 2025. The recommendations made by the group reflect consensus among WSAC members for how best to address an agreed-upon worst year gap of 1.2 billion gallons between water supply and water demand during times of extended drought. The strategies recommended include: (1) strengthened water conservation programs; (2) storage of available San Lorenzo River flows during the rainy season in regional aquifers, through processes known as “In Lieu” water transfers, for passive recharge, and Aquifer Storage and Recovery (ASR) for active recharge; and (3) a supply augmentation plan to use advanced-treated recycled water with desalination as a back-up, should the use of advanced-treated recycled water not be feasible. The Committee’s Plan accomplishes the City’s water supply goal while providing robust instream flows to support and enhance fish habitat restoration and protection.

Specifically, the second element of the City’s Water Supply Reliability plan is required in order to implement improved instream flows or “Conservation Flows” described in this HCP. The elements of this strategy that the City may implement to ensure sufficient water supply to implement the HCP are referred to as the Santa Cruz Water Rights Project and include:

- An extension of time to perfect the City’s Felton Diversion water rights
- Alignment of all City’s water rights place of use (POU) designation
- Flexibility in use of City’s San Lorenzo River water rights points of diversion (POD)
- Addition of direct diversion to the City’s Felton and Newell Creek water rights
- Improvements to the Graham Hill Water Treatment Plant that will enable more use of turbid winter high flows.
- Development of underground storage rights for diverted high winter flows.
- Designation of “Conservation Flows” for the City’s San Lorenzo River and North Coast water rights

These changes will enable better use of high winter flows in the San Lorenzo River (primarily diverted from the Tait Street Diversion) to assist recharge of regional aquifers and enable supply reliability. This will provide additional water storage for the City for drought periods and generally support implementation of groundwater sustainability plans in their efforts to protect impacted groundwater basins such as the Santa Margarita and Mid-County basins. Each of the changes involving the City’s water rights would be integrated with the addition to those rights of key environmental requirements. The Conservation Flows for fisheries conservation that the City has developed in close coordination with CDFW and NMFS would be added as minimum flow requirements that must be met before diversions occur in the applicable streams. In addition, requirements for fish passage and screening improvements at City diversion facilities would be added to the City’s water-right permits and licenses that authorize diversions at the respective facilities (as described in Section 3.3.1 - Water Diversions). Minimum flow requirements would be added to the City's pre -1914 water rights in the North Coast streams through the Santa Cruz City Council's adoption of a resolution amending those rights. Minimum San Lorenzo River flow requirements would be added to the City's Felton water-right permits and its Tait Street water-right licenses through the City's water-right petitions to the SWRCB and the SWRCB's approval of those petitions.

The City's approach to water supply, and the required approvals by the State Water Resources Control Board, are foundational to regional water supply reliability and the City's ability to effectively implement the HCP.

6.2.2 Administrative Structure for Roles and Responsibilities for Implementation

The HCP Administrator will be housed in the Santa Cruz Water Department (SCWD) and will provide for coordinated and effective implementation of the Plan. The HCP Administrator will have the following roles and responsibilities:

- Financial planning and management of funding for habitat protection and biological and compliance monitoring.
- Reporting on Plan implementation, including annual accounting of activities.
- Maintenance and updates of the monitoring database on habitat, Covered Species, and other relevant information.
- Program implementation and coordination, including coordination between the City and NMFS.
- General administrative support for the above activities, including support personnel, accounting, facilities, and equipment.

6.3 Role of National Marine Fisheries Service

NMFS' role and responsibilities under the Plan include:

- Conferring with the HCP Administrator regarding Plan implementation.
- Participating in the adaptive management and monitoring program.

- Participating in the TAC.
- Providing assistance to third parties engaged in activities in the Plan Area to help ensure that such activities proceed in compliance with State and federal endangered species laws and in a manner that does not compromise the likelihood of success of the Plan.

6.4 Monitoring Program

The HCP monitoring program will provide the information necessary to assess compliance with the terms of the HCP, verify progress toward the biological goals and objectives, and implement a feedback loop to ensure that management/mitigation measures of the HCP can be changed as needed in response to changing conditions and new knowledge. The monitoring program will be flexible to allow addition of new monitoring techniques or modification of monitoring methods that are not obtaining needed information. The monitoring program will be overseen by the HCP Administrator and methods and results will be reported in an annual monitoring report.

The monitoring program outlined below will provide data on the distribution and abundance of the Covered Species, their habitats, and potential threats within the Plan Area. Using these data, the City will be able to assess changes in the quality and quantity of the specific habitat of the Covered Species, identify significant changes in the populations of the Covered Species, measure progress towards meeting the HCP's biological goals and objectives, and decide if changes in management or monitoring are warranted. The results of the annual monitoring activities will also inform management decisions, including selection of projects to be funded from the NFCF.

All monitoring activities will be performed under the HCP Administrator's guidance and supervision, or under the guidance and supervision of a designated Conservation Program Manager. Prior to the implementation of the HCP, the Conservation Program Manager will prepare a monitoring manual that specifies the methods and protocols to be used in the Monitoring Program. Training will be provided for all individuals performing monitoring activities and these individuals will have qualifications, knowledge, and experience relevant to the type of research and monitoring activities that are being performed. A list of all individuals who participate in the monitoring activities and copies of training materials will be submitted to NMFS with the Annual Monitoring Report. The HCP Administrator may engage third parties (such as biological consultants with specific technical expertise regarding a Covered Species) who are qualified and authorized by NMFS to conduct, or to directly supervise, activities conducted under the HCP's monitoring program.

Monitoring program coordination with NMFS and CDFW will be achieved through regular meetings (at least one to two per year) of a Monitoring Technical Committee (MTC). Meetings will include a review of results of the past seasons monitoring and finalization of plans for the upcoming monitoring season. The value of existing studies will be appraised and monitoring elements may be revised accordingly.

6.4.1 Compliance Monitoring

The City is committing to meeting instream flow targets, operational constraints, and facility upgrades as avoidance and minimization measures under the HCP. The compliance monitoring element addresses these commitments. Annual monitoring and reporting will be completed to demonstrate compliance with the terms and conditions of the permit, including incidental take limits (see Chapter 5 for determination of incidental take under this HCP). An annual compliance monitoring report will be completed with monitoring procedures and results as specified in the following areas:

- Incidental take tracking: The major effect of Covered Activities on listed salmonid species is alteration of habitat related to the City diversions and water supply facilities (Chapter 5). It is anticipated that operation of the City's diversion facilities and performance of other activities in conformance with the associated operating procedures and bypass flow requirements will maintain instream flow conditions in a manner that adequately protects and conserves habitat downstream of City water diversions. If operation of the City's facilities creates flow conditions which deviate from the bypass flow requirements, the anticipated level of incidental take caused by the proposed action will be exceeded. Therefore, tracking of incidental take will primarily involve documentation of flows and operating procedures as a surrogate for habitat. The annual compliance monitoring report will include an accounting of incidental take for each of the Covered Activities, including take associated with capture and including total number and any incidental mortality.
- Instream flow targets: The City will continue to maintain a streamflow monitoring network and to report anadromous gage daily flow records for Liddell (anadromous and upper), Laguna (anadromous, below diversion, above diversion), Majors (anadromous, below diversion, above diversion), Newell (upper and below dam), Felton (below the diversion), and Tait Street (below the diversion). The monthly exceedance category based on cumulative flow at the Big Trees gage[58] will be calculated and compared to the flow record at each gage to document compliance with appropriate instream bypass

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[58] See Section 4.4 for description of exceedance categories and bypass flow prescriptions.

flows. Results of streamflow monitoring and analysis to document compliance with flow targets will be provided in the annual HCP monitoring report. Interim reporting will occur on an as-needed basis whenever the City determines that it is out of compliance with provision of bypass flows or is expecting to be out of compliance at some point in the future. This could result from facility outages, extreme weather conditions, or other unforeseen circumstances. Specific criteria and procedures for notification will be established by the MTC as part of implementation of the HCP.

- Felton Diversion operations: A description of the Felton Diversion operations is provided in Section 3.3.1 and minimization and avoidance of effects are described in Section 4.4. The City will provide a record of dam operations (Operations Log), including dates when fully inflated, deflated, partially inflated; position of slide gate, dates of operation and counts at the fish trap. Any issues involving fish ladder maintenance; fish screen maintenance; observation of sediment accumulations or sediment transport issues will also be reported with a focus on what did not work rather than details of what was done. These records will be included in an annual HCP monitoring report.
- Copper monitoring at Newell Creek Reservoir (Section 3.3.2, Section 4.4.2.2): The City will include an annual monitoring report as specified in the Aquatic Pesticide Application Plan, including dates of treatment and copper concentrations at standard measurement sites in the annual HCP monitoring report.
- Testing deluge and gate valves (Section 3.3.2, Section 4.4.2.2): The City will provide an annual report documenting the dates of testing, flows, and quality of water released to Newell Creek (temperature, turbidity, DO concentrations) measured at standard sampling points downstream.
- Relocation of LWD downstream of Loch Lomond Reservoir (Section 3.3.2, Section 4.4.2.2): During the dry season the City will remove tree trunks and limbs that collect at the dam and place them in areas downstream of Newell Creek where they can provide habitat for rearing juvenile salmonids. The City will include an annual report documenting the number and dimensions of material moved, dates, and locations of placement in the annual HCP monitoring reports.
- Installation of Sediment Management upgrades at Laguna, Reggiardo, and Majors Diversions (Section 3.3.1, Section 4.4.2.1): The City will install sediment management upgrades and sediment removal practices as specified in Streambed Alteration Agreements reached with CDFW. The City will include documentation of sediment management activities including dates, amount of sediment removed, etc., and dates for installation of upgrades in the annual HCP monitoring reports.
- As part of the Covered Activities, Fish Screen Upgrades and juvenile bypass improvements will be installed at the Felton and Tait Street Diversions. These activities will be documented in the annual HCP monitoring report, including a project description

and date for installation. Monitoring of screen operation after installation will be provided under the Felton Diversion Operations Log (see previous).

- Water System Operations and Maintenance (Section 3.4, Section 4.4.2): The City will document operations completed for conveyance pipeline repair, finished pipeline flushing or repair, well return to San Lorenzo River, NC blow off to San Lorenzo River in the annual HCP monitoring report. This will include dates, description of the activity, and possible effects on steelhead, coho or habitat. The intent of this element is to demonstrate compliance with the terms of the HCP, and specifically to demonstrate that the avoidance and minimization measures are followed and completed.
- Municipal Facilities Operations and Maintenance (Section 3.5, Section 4.4.4): The City will provide a report on operations completed for debris/obstruction removal, sediment removal, and vegetation removal in the annual HCP monitoring report. Any fish protection operations completed will be described along with the numbers and species of fish captured, their disposition, and any losses encountered. There will also be a narrative description of potential effects on steelhead, coho, or their habitat.

6.4.2 Mitigation Effectiveness Monitoring

The mitigation effectiveness monitoring element addresses the non-flow component of the conservation strategy. The mitigation strategy is based on a stepwise process of habitat enhancement that will occur over the life of the HCP. The City will provide annual funding for projects, and a TAC will decide on projects and allocate funds (see Section 4.5 for a description of the mitigation program). Ongoing monitoring of mitigation efforts is important to verify or correct current assumptions, choose the best course of action to ensure that future efforts are based on the best available science, ascertain whether the Plan is achieving its biological goals and objectives, and provide information used to revise methods if necessary to improve attainment of biological goals and objectives. The proposed mitigation strategy is compatible with an adaptive management approach in that funding decisions for mitigation measures will be made on an annual basis and will reflect the current knowledge base and status of the species. Decisions on implementation of specific projects will be informed by the success of past measures as determined through specific monitoring studies addressing the mitigation measures. Monitoring and reporting will be conducted for each mitigation project implemented (see Individual Project Monitoring, below), and annual and five-year reporting of the overall mitigation program will be provided.

6.4.2.1 Individual Project Monitoring

Each mitigation project will be monitored after 1, 3, 5, and 10 years. Reporting for each mitigation project will be provided in the annual and five-year mitigation summary reports and will include information on attainment of project-specific success criteria (via review of assessment variables to be prescribed for each project by the TAC), responsible party, specific monitoring methods, a schedule of monitoring activities, analytical methods, and reporting requirements.

6.4.2.2 Annual and 5-Year summary Report

Annual reporting for the mitigation effectiveness monitoring will include the level of funding provided to the TAC for the year and a description of the projects implemented with that funding. The rationale for project selection and its relationship to effects to be mitigated under the HCP will be described. The HCP annual report will also incorporate a listing of all mitigation projects involving City funding implemented to-date together with their status as complete or not, an assessment of their success, and an accounting of City funds allocated to each project to date. Every five-year HCP update report will include a synopsis of effectiveness monitoring results for each project completed during the five-year period.

6.4.3 Population and Habitat Monitoring

This monitoring element addresses the status of Covered Species populations and habitat. Population and habitat monitoring will be consistent with the CMP (Adams et. al 2011). The CMP is a coordinated effort involving CDFW and NMFS with the goal of measuring progress to recovery of listed species under CESA and ESA listings. The City ’s HCP requires monitoring to evaluate levels of take and effects of the City’s activities on populations and habitat of covered species. To the extent that these efforts have common goals, the City’s monitoring program can contribute to the wider evaluation of population status at the regional level.

The methodology of the CMP is still under development and implementation of the program is ongoing. There are limitations to monitoring capabilities and differing priorities between the CMP and City monitoring goals that still need to be resolved. For example, the CMP design calls for different objectives and methods in Northern Area (Aptos Creek and north) and Southern Area (Pajaro River and south). The HCP area, and especially the San Lorenzo River, is on the boundary and though technically in the Northern Area, it has much in common with the Southern Areas and may be better approached from that perspective. Methodological limitations in the HCP streams will need to be addressed as well. The most problematic of these include: inability to distinguish juvenile steelhead from juvenile resident trout in snorkel or other surveys;

diver health considerations for snorkel surveys in the San Lorenzo River; effects of high stream flow and poor visibility for conducting redd surveys; and security of remote monitoring equipment installations, especially on the San Lorenzo River.

It is anticipated that there will be a period of initial development of the monitoring program that is best accomplished through a MTC composed of both Agency (CDFW and NOAA) and City representatives. The MTC may be a sub-committee of the HCP TAC. The MTC will ensure consistency with the CMP and this process will yield the most rigorous approach to resolving monitoring issues identified. For this reason, the monitoring program presented here should be viewed as an initial representation of the program that will be refined as it is implemented. It should be recognized that there needs to be some flexibility in the design to allow for incorporation of improvements resulting from better definition of the CMP and possible technological advances in monitoring methods over time. The monitoring elements are described here from the perspective of current monitoring efforts, modifications consistent with the CMP, and recognition that the final design will come under the guidance of a MTC to reflect the state of the art in regional salmonid assessment and to ensure consistency with regional efforts as they develop. Details for each monitoring element, including key measurement variables, methods, location, frequency, and timing, are also provided in Table 6-1.

Unless noted otherwise, field monitoring programs will follow established protocols from published sources including the Salmonid Field Protocols Handbook (Johnson et al 2007), California Salmonid Stream Habitat Restoration Manual (Flossi et al. 1998), California Coastal Salmonid Population Monitoring: Strategy, Design, and Methods (Adams et. al 2011), the Central California Coast Coho Salmon Recovery Plan (NMFS 2012), and other peer-reviewed scientific literature. Detailed monitoring protocols will be developed and refined within the context of the MTC. At five-year intervals the City will review the monitoring program in association with representatives of NOAA and CDFW and the value of existing studies will be appraised and monitoring elements may be revised accordingly.

6.4.3.1 Steelhead and Coho Population Viability

The CMP uses the Viable Salmonid Population (VSP) (McElhany et. al. 2000) concept as the framework for plan development. The VSP conceptual framework assesses salmonid viability in terms of four key population characteristics: abundance, productivity, spatial structure, and diversity (Adams et al. 2011). The City's monitoring program, as described below, is designed to be consistent with this framework. The City will also collaborate on an informal basis with other agencies to share information providing population abundance monitoring over a wider area, including areas outside the Plan Area and wider ESU level trends. For example, NMFS has operated a life-cycle research station in Scott Creek where detailed information is collected on rearing abundance, smolt migration, and adult return rates of steelhead and coho. This research provides valuable information for addressing the effects of marine survival on salmonid populations and distinguishing these effects from those derived from freshwater survival and productivity. The City will refer to the information from this and other stations to make inferences and comparisons and interpret the abundance data it collects.

Abundance and Productivity

The CMP uses adult population size as the key measure of abundance and productivity (trend in abundance over time). Adult abundance monitoring is approached differently in the Northern and Southern Areas with expanded redd surveys in the North and counts at fixed stations in the South (Adams et al. 2011).

Current abundance monitoring in the HCP area involves annual snorkeling surveys for juvenile abundance in the anadromous reaches of Liddell Creek, Laguna Creek, and Majors Creek and annual quantitative electrofishing in the San Lorenzo River watershed. In order to be consistent with the CMP, abundance monitoring would be shifted to adults and the emphasis of juvenile monitoring would be shifted to measuring spatial structure and diversity (see below).

The CMP uses a combination of fixed station total adult census in selected intensively monitored watersheds (Life-cycle monitoring stations), and regional redd surveys to estimate total salmon and steelhead abundance on a region wide scale. CDFW has previously conducted regional adult spawner surveys in Santa Cruz Mtn streams although this monitoring is no longer occurring (Sean Cochran, CDFW, personal communication, January 2021). For the San Lorenzo River, total adult population is the monitoring objective and therefore a fixed station count is the most appropriate method. Redd surveys in the San Lorenzo River may have some utility as a complement to fixed station counts, particularly in parts of the watershed that may be missed by fixed station counts. The potential for redd surveys in Liddell, Laguna, and Majors Creeks should be explored though the small size and complex habitat in these streams may be problematic in terms of disturbance to spawning fish, damage from walking on redds, and ability to observe redds and/or spawning fish, especially with the small run sizes likely to occur in the short anadromous reaches.

The trap at the Felton Diversion Dam offers a potential opportunity for a fixed station counting location. The trap would have to be combined with other methods such as a DIDSON[59] camera

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[59] Dual-Frequency Identification Sonar (DIDSON) is an acoustic “camera” that has been adapted to fisheries monitoring (Maxwell and Gove 2004). The device is a high-frequency sonar system with a lens capable of focusing sound waves onto a high-resolution sensor array.

or PIT tag monitoring to achieve an estimate of the adult population passing Felton. Adult trapping can be used to enumerate; tag (external spaghetti or PIT); identify species and sex; examine for scars, parasites, and body condition; and collect tissue samples for genetic analysis and scales for life history analysis from captured listed species. The Monterey Bay Salmon and Trout Project is a potential partner for this work. A drawback of the Felton location is that any fish spawning lower in the watershed (Gorge, Branciforte Creek) would not be counted. A fixed station count lower in the watershed, such as at the Tait Diversion, would be necessary to overcome this limitation. This could be accomplished by a resistance weir in the lower river, possibly in conjunction with the Tait Diversion structure; a trap at the diversion; or a DIDSON installation. DIDSON has the advantage of being operable at higher flows than a resistance weir and avoiding the elaborate structure and equipment requirements of a trap or weir. The drawback is that it is unable to accurately distinguish species, steelhead and coho for example. Any count at the Tait Diversion would also fail to incorporate fish using the Branciforte watershed.

Spatial Structure and Diversity

The CMP uses spatial structure and diversity as measures of population viability. Spatial structure refers to the geographical and ecological distribution of salmonids across the landscape. Broad spatial distribution and connectivity among populations are important traits that protect against the effects of catastrophic events and buffer extinction risk, particularly at low abundance. Although some information on spatial structure can come from adult surveys where redd surveys are conducted, the CMP proposes using visual (snorkel) surveys for juvenile salmonids as the most efficient means to monitor spatial structure (Adams et al. 2011). A larger number of juvenile surveys can be accomplished in less time and expense than adult surveys because it is simpler and can occur at a more operationally favorable time of the year. Snorkel surveys are also more efficient than electrofishing surveys, allowing a wide geographic area to be surveyed. Under the CMP, the key elements of measuring spatial structure are distribution and relative abundance on a regional scale, not population abundance quantification per se.

The City currently conducts snorkel surveys in the fall of the year to estimate the abundance of juvenile steelhead and coho in Liddell Creek, Laguna Creek, and Majors Creek. The City also contributes funding to Santa Cruz County and research partners for annual surveys of juvenile abundance in the San Lorenzo River system including Newell Creek. The San Lorenzo River survey has been implemented since 1997 and develops population abundance data using a combination of depletion electrofishing (DW Alley and Associates 2010) and visual (snorkel) surveys in larger, deeper pools that are not effectively sampled by electrofishing. The San Lorenzo surveys emphasize a basinwide abundance estimate for both young-of-year and older juveniles but also allow for comparisons between defined subreaches within the watershed. The

City also conducts abundance surveys in Laguna Creek Lagoon and the San Lorenzo River Lagoon using beach seines. The beach seining surveys employ mark-recapture techniques and PIT tagging to estimate population size in each of the lagoons.

City snorkel surveys in the North Coast streams are consistent with the CMP as currently conducted. Although the CMP sampling scheme may not select these reaches in any given year, the data would be available for incorporation whenever selected. Annual data provides a finer grain than required under the CMP but it is useful under the HCP as an indicator of status and trends relative to operation of the City diversions.

The current annual electrofishing/visual surveys in the San Lorenzo River and Newell Creek are not consistent with the CMP due to 1) different definition of reaches, 2) primary use of electrofishing instead of snorkeling and, 3) use of a subjective representative site selection method instead of random sampling. The lack of random sampling under the current surveys prevents rigorous statistical analysis for comparison of annual or spatial differences in abundance. Nevertheless, the current surveys include a long term, consistently sampled dataset that has value even if not consistent with the CMP methods and should not be abandoned lightly. A comparison of the non-random methodology with a more rigorous randomized sampling scheme conducted in 2002 found that both methods gave generally comparable results in terms of parameter estimates for both habitat features and steelhead abundance (H.T. Harvey & Associates 2003a). The chief advantage of the randomized sampling is that it provides a statistically rigorous basis for spatial and temporal comparisons that the non-randomized design does not.

Under the HCP, the City will monitor juvenile salmonid spatial structure and distribution by conducting annual juvenile surveys during the late summer or fall by either snorkeling or electrofishing. The juvenile surveys will be conducted within a statistically valid spatially balanced sampling design, consistent with the CMP (Adams et al. 2011), using established sampling protocol in salmonid monitoring literature (Johnson et al. 2007; Boughton 2010, Hankin and Reeves 1988). Snorkel surveys are generally preferred as they can cover a wider area for a given level of effort than electrofishing. On the other hand, electrofishing is advantageous for collecting more precise size data and providing an opportunity for PIT tagging. Snorkel surveys may be precluded in some areas due to lack of landowner approval for access, excessively deep pools, dense cover, concerns for diver health due to poor water quality, and other safety concerns. The general random tessellation stratified (GRTS) sampling scheme can easily accommodate unusable sample reaches (Adams et al. 2011). It is also likely that the City will add samples in segments of the San Lorenzo River that are influenced by City water diversions in order to allow evaluation of status and trends within the sub-watershed areas affected by altered flow regimes. The GRTS framework also allows for augmented sampling for domain estimates (Adams et al. 2011). The City monitoring program will be more fully defined by the MTC before full implementation and may change in response to evolution of the CMP. Any changes will be addressed through the MTC.

The City sampling frame will include all reaches in the San Lorenzo watershed downstream of operations (San Lorenzo River downstream of the Newell Creek confluence and Newell Creek below the Newell Creek Dam), and the anadromous reaches of Laguna Creek, Majors Creek, and Liddell Creek. To provide statistical integrity, the City surveys will conform with spatially balanced reaches designated by CDFW using a GRTS sampling scheme (McDonald 2004; Adams et al. 2011). The use of a common spatial sample scheme is to provide consistency in the sampling universe, so that data gathered is spatially comparable (Adams et al. 2011). This will allow for future coordination with other conservation partners and the fishery agencies for a complete assessment of the watershed. Juvenile surveys conducted under the HCP will be more intensive than envisioned in the CMP and will likely include the entire reaches affected by City operations. Consistency with the CMP will be maintained by structuring sampling within the GRTS reaches identified in the CMP and by developing and reporting data with the same methodologies employed in the CMP.

Juvenile Abundance and Spatial Distribution- Lagoons

The City will monitor rearing populations of juvenile steelhead and coho in Laguna Creek Lagoon and the San Lorenzo River Lagoon (the only two streams with functional lagoon systems) on an annual basis using seining surveys. Population abundance in each lagoon will be estimated from Petersen mark-recapture methods (Ricker 1975) using PIT tag technology and catch per unit effort (CPUE). Population abundance will be estimated in June and September at a minimum and intervening status checks may also be conducted, with or without tagging and population estimates. Seining is conducted at standard sampling sites within each lagoon which are largely determined by accessibility and suitability for use of seine equipment (HES 2009, HES 2010, HES 2011, HES 2012, HES 2013, HES 2014a, HES 2015, HES 2016, HES 2017).

PIT Tag Monitoring Antenna

Although not specifically identified as a component of the CMP, PIT tag monitoring can provide valuable supplemental information and will be performed in the San Lorenzo River. A PIT tag monitoring antenna is currently maintained by the NOAA Southwest Fisheries Science Center below the Felton Diversion. The City will install an additional antenna in the lower river, potentially at the Tait Street Diversion and/or Branciforte Creek. This supports both juvenile monitoring and adult monitoring. PIT tags will be placed in juveniles during electrofishing and seining surveys and in adults during trapping at the Felton Diversion Dam (see above).

Installation and maintenance of a PIT tag antenna array in the San Lorenzo River will allow the City to passively monitor movement of tagged individuals (Johnson et al. 2007; Boughton 2010) including movement of juveniles or smolts tagged during stream electrofishing surveys, movement of juveniles tagged in lagoon seining surveys, and movement of adults tagged in the Felton Diversion Dam trap. Using PIT antenna data, the City can identify life history strategies, identify movement and migration timing across habitats, and quantify trap capture efficiency. The NOAA Southwest Fisheries Science Center is a potential partner for this work.

6.4.3.2 Steelhead and Coho Habitat Quality

Instream flow targets are keyed to existing channel structure and habitat conditions. Habitat conditions may shift in response to flow management under the HCP and due to a variety of other factors, including altered hydrology and vegetation under climate change, wildfires, drought, and increased development. Changes in habitat quality will be monitored to better understand any observed changes in population abundance. Habitat monitoring will involve both instream habitat and lagoon habitat. Habitat assessment methods should be consistent with existing accepted methods (Flossi et al. 1998) or with the CMP which have not currently been developed. The City monitoring program may change in response to evolution of the CMP. Any changes will be addressed through the MTC.

Instream Habitat

Instream habitat will be surveyed by the City following the occurrence of a 5 year or larger flow event (as measured at the Big Trees USGS gage) in the anadromous reaches of Liddell Creek, Laguna Creek, Majors Creek, Newell Creek, and the San Lorenzo River downstream of Newell Creek Dam. The habitat survey will include detailed characterization of stream habitat conditions in accordance with the California Salmonid Stream Habitat Restoration Manual (CDFW Method) (Flossi et al. 1998) or other appropriate methodology determined by the MTC. Surveys will include: channel instream habitat typing, quantification of stream habitat by mesohabitat type (riffle, pool, flatwater, etc.) including length, width, depth, substrate characteristics (embeddedness and dominant substrate), instream shelter characteristics, and canopy characteristics. Habitat surveys will occur with reference to the CMP GRTS reaches. Habitat monitoring will also include periodic evaluation of passage obstacles including critical riffles and other obstacles to ensure that minimum passage flow levels previously estimated remain valid. Critical riffles will be evaluated using methodology agreed upon by the MTC (e.g. the Standard Operating Procedure for Critical Riffle Analysis for Fish Passage in California (CDFW 2012)). Reports will include a compilation of results and summary of trends over the previous reporting period. The SLVWD, Scotts Valley Water District (SVWD), and County of Santa Cruz are potential partners for this work.

Instream Temperature

Current water temperature conditions are well within suitable ranges for steelhead and coho in North Coast streams but may be limiting in parts of the San Lorenzo River, particularly for coho (Chapter 2). Global climate change may alter temperature regimes in all these streams. A water temperature monitoring network will be established using continuous instream recorders set to record at 30-minute intervals. Recorders will be placed annually during the period of maximum thermal loading (May 1 through September 30). Recorders will be placed to avoid discovery and will be downloaded on a monthly basis. Recorders will be maintained at the following locations:

- Laguna Creek (2): Below diversion and anadromous
- Liddell Creek (2): Below diversion and anadromous
- Major Creek (2): Below diversion and anadromous
- San Lorenzo River (4): Upstream of Water St in the riverine reach, Tait Street, Gorge, Ben Lomond upstream and downstream of Newell Creek confluence
- Newell Creek (2): Below dam (fish release outlet) and anadromous (Glen Arbor)

Water temperature monitoring protocols will be developed in advance and approved by the TAC. Protocols for monitoring and analysis will follow accepted methods as presented in the scientific literature (e.g. US EPA 2014, Toohey et al. 2014, Dunham et al. 2005). The temperature monitoring plan will specify standardized protocols and data-quality standards to produce generally consistent, unbiased, and reproducible data. The program will include definition of data-quality objectives, site selection criteria, selection of instrumentation, protocols for installation of sensors, schedule of periodic site visits to maintain sensors and download data, pre- and post-deployment verification against an NIST-certified thermometer, potential data corrections, database management and proper documentation, review, and approval procedures.

Lagoon Habitat

Lagoon habitat quality conditions will be monitored annually by the City in both the Laguna Creek and San Lorenzo River lagoons[60] consistent with previous surveys conducted since 2004 (2NDNATURE 2017, 2NDNATURE 2006). Water quality monitoring will document patterns of DO, temperature, salinity, tidal and freshwater inflow, climate, lagoon stage, lagoon volume, and nutrients throughout the water column and along the length of both lagoons during the late

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[60] Majors Creek and Liddell Creek do not have functional lagoons.

spring, summer and fall months when they provide important rearing habitat for steelhead smolts. Data will continue to be collected at two standard monitoring locations as well as periodic profiles of these same parameters at an additional 6 standard sampling locations at regular intervals throughout each lagoon. Winter water surface elevation data will also be collected and assessed annually to help evaluate lagoon breach dynamics.

Table 6-1: Salmonid Population and Habitat Monitoring Elements

Monitoring Element	Source	Key Measurement Variable(s)	Method	Location	Frequency	Timing
Population Abundance-Juvenile	City of Santa Cruz	Count per 100 ft. of stream by age class	Spatially balanced snorkel survey and per CDFW CMP protocol.	Liddell Creek Laguna Creek Majors Creek	Annually	Fall
Population Abundance-Juvenile	City of Santa Cruz	Count per 100 ft. of stream by age class	Spatially balanced electrofishing/ snorkel survey per CDFW CMP protocol.	Newell Creek Dam downstream to Water St.	Annually	Fall
Population Abundance-Juvenile	City of Santa Cruz	Total population estimate	Seine: Petersen Mark-recapture with PIT tags	Laguna Creek Lagoon San Lorenzo River Lagoon	Annually	Early Summer/Fall
Population Abundance Adult	City of Santa Cruz	Adult Escapement Sex ratio	Trap/DIDSON/PIT counting station	Felton Diversion Dam	Annually	December-April
PIT tag antenna array	City of Santa Cruz	Juvenile and adult movement	Passive antenna	San Lorenzo River-specific location to be determined	Constant	Year around
Stream Habitat	City of Santa Cruz	Channel cross-section Habitat type composition Wetted width Mean and maximum depth Instream cover Spawning area Gravel embeddedness Dominant substrate	California Salmonid Stream Restoration Manual, Level IV	Anadromous reach: Liddell Creek Laguna Creek Majors Creek Newell Creek Dam downstream to Water St.	Subsequent to each 5-year flood event as measured at Big Trees USGS gage	Late Summer

Table 6-1: Salmonid Population and Habitat Monitoring Elements (continued)

Monitoring Element	Source	Key Measurement Variable(s)	Method	Location	Frequency	Timing
Instream temperature	City of Santa Cruz	Water temperature (°C) accuracy +/- 0.1 °C	Instream continuous temperature recorder	Below Laguna Diversion Anadromous Laguna Below Liddell Diversion Anadromous Liddell Below Majors Diversion Anadromous Majors San Lorenzo River above Water St. in riverine reach San Lorenzo River at the Tait Street Diversion San Lorenzo River Gorge San Lorenzo River upstream and downstream of Newell Creek Newell below Dam Anadromous Newell (Glen Arbor)	30 minutes	May 1-September 30
Passage Obstacles	City of Santa Cruz	Minimum passage flow estimate	CDFW Critical Riffle Analysis Powers and Orsborn California Salmonid Stream Restoration Manual	Anadromous reach: Liddell Creek Laguna Creek Majors Creek Newell Creek San Lorenzo River below Tait Street San Lorenzo River gorge	Subsequent to each 5-year or larger flood event as measured at Big Trees USGS gage	Winter high flows and summer low flows
Lagoon Habitat	City of Santa Cruz	Dates open and closed Depth/Water surface elevation (WSE) Thermal record DO record Salinity Nutrient concentrations	Continuous recorder at mid-point; monthly profiles at set stations	Laguna Creek Lagoon San Lorenzo River Lagoon	Annually	May-November WSE Year-round

		Aquatic veg. types and area				

6.4.4 Adaptive Management Process and Options

Monitoring results will be used to guide management activities to help ensure attainment of the HCP goals and objectives. Steelhead and coho life cycles are typically completed in three to five years. The City's adaptive management planning will be completed in five-year review periods. This time period allows for data capture covering different life-stages and inherent population fluctuations due to timing of fish maturity and annual weather cycles. Each five-year review will be based on a summary report for the preceding five-year period. The report will integrate information in the annual reports for the review period and describe population abundance trends and habitat quality changes since the last review. Biological parameters will be compared with any observed changes in physical parameters or project operations to identify possible linkages. Progress and level of attainment of each of the HCP goals and objectives (Section 5.3) will be summarized.

The conservation strategy is designed to support improved habitat conditions relative to the current condition with the implication that populations of steelhead and coho will be benefited and that population parameters would also respond in a positive fashion. The key evaluation factor triggering the need for adaptive management under the HCP is a lack of improvement in habitat values for Covered Species. Habitat indices (average spawning or rearing WUA, annual number of days meeting adult or smolt migration criteria) provide logical assessment variables and lack of improvement in any of these indices, relative to conditions existing before implementation of HCP related improvements, could trigger adaptive management actions. Declining habitat values may also be indicated by trends in lagoon habitat parameters (depth, temperature, oxygen, salinity, and vegetation characteristics); trends in stream temperatures; or trends in stream habitat parameters (channel cross-sections, critical riffle analysis; mesohabitat proportions; substrate composition; instream cover characteristics, etc.). Parameter values are assessed over appropriate time frames using valid statistical approaches. A minimum period of three to five years will likely be necessary for identifying significant trends.

The Plan Area is only a subset of the wider geographic areas that are the basis for population recovery under the ESA. It is anticipated that others (NMFS, CDFW) will be conducting monitoring programs that address population viability over these wider geographic areas (Crawford and Rumsey 2011). Monitoring conducted by the City under the HCP and within its limited geographic range may augment but will not replace these efforts. Data from the wider recovery area must be considered in addressing long-term viability and this data will provide an important context for evaluating monitoring data collected by the City within the HCP plan area.

The HCP monitoring program will produce a large amount of data from which habitat indicators may be drawn. These may include:

Instream Habitat

- Average life-stage WUA for spawning and rearing (based on streamflow monitoring and existing habitat models)
- Days with suitable passage conditions for adults and smolts
- Maximum seven-day moving average of daily maximum temperature
- Maximum seven-day moving average of daily average temperature
- Quantification of stream habitat by mesohabitat type (riffle, pool, flatwater, etc.) including length, width, depth, substrate characteristics, instream shelter characteristics
- Channel type definition
- Channel cross-section
- Stream bank and canopy characteristics
- Instream cover characteristics
- Spawning area
- Dominant substrate and gravel embeddedness

Lagoon Habitat:

- August average daily inflow (cfs)
- Dates of sandbar closure (initial and final)
- Number of days of sandbar closure between May 15 and October 1
- Number of days of microtidal conditions between May 15 and October 1
- Mean of daily average water depth or lagoon stage (July and August)
- Minimum water depth or lagoon stage (July and August)
- Seven-day moving average of daily maximum air temperature (July and August)
- Seven-day moving average of daily maximum surface water temperature (July and August)
- Number of days with daily maximum surface temperature exceeding 25°C
- Number of days with daily maximum surface temperature exceeding 21°C

Should the monitoring data indicate a consistent declining trend or lack of improvement in habitat conditions relative to conditions existing before implementation of HCP related improvements, the City will implement adaptive management responses. The need for adaptive management decisions and actions will be an ongoing process best pursued within the TAC and will be based on trends in the monitoring data and in consideration of the biological goals and objectives of the HCP. Adaptive management actions may be based on declines in habitat indicators or lack of improvement in those indicators. Many of the indicators have been measured during development of the HCP and some have long-term datasets of 10 years or more. These indicators will be used as a baseline for comparison of the first five years of the HCP. For other indicators with shorter data histories or no previous monitoring, trends will be evaluated during the first five years of monitoring and this period will serve as a baseline for future monitoring. For a number of reasons, including that coho numbers in the Plan Area are essentially zero due to local extirpation and very low, sporadic abundance in recent years, habitat indicators have been selected for understanding baseline conditions instead of population counts.

Outcomes of the adaptive management decision making process can include, within the limits set by the HCP and permit, changes to choice of conservation projects, monitoring programs, analytical tools, and targets. There are other factors in addition to controlling streamflows and improving stream and lagoon habitat that contribute to the long-term persistence and viability of steelhead and coho populations in the HCP area, including:

- ESU/DPS wide and regional trends in target species populations
- Climate change, precipitation patterns, temperature trends, ocean productivity
- Fish health / disease factors
- Invasive species
- Watershed conditions, surface water/groundwater interactions

Changes in any of these factors may trigger adaptive management decisions under the HCP. These factors, many not fully understood, are being monitored by other agencies. Through monitoring and continued information exchange with the fishery agencies, and in coordination with NMFS review and approval, the City may modify non-flow conservation and monitoring programs to address new information in these areas.

6.5 Regulatory Assurances and Changed Circumstances and Unforeseen Circumstances

6.5.1 Regulatory Assurances

ESA regulations provide for regulatory and economic assurances to parties covered by approved HCPs concerning their financial obligations under a plan, as long as a permittee is implementing the requirements of the HCP, permit, and other associated documents in good faith, and their permitted activities will not jeopardize the species. Specifically, these assurances are intended to provide a degree of certainty regarding the overall costs associated with species mitigation and other conservation measures and add durability and reliability to agreements reached between permittees and NMFS. That is, if unforeseen circumstances occur that adversely affect species covered by an HCP, NMFS will not require additional land, water, or financial compensation or impose additional restrictions on the use of land, water, or other natural resources, unless the permittee consents.

The assurances provided under the ESA do not limit or constrain NMFS, or any other public agency, from taking additional actions to protect or conserve species covered by an HCP. The state and federal agencies may use the variety of tools at their disposal and take actions to reduce the effects of other stressors to ensure that the needs of species affected by unforeseen events are adequately addressed.

6.5.1.1 Regulatory Assurances Under the ESA – The No Surprises Rule

Under the No Surprises Rule, once an incidental take permit has been issued pursuant to an HCP, and its terms and conditions are being fully implemented, the federal government will not require additional conservation or mitigation measures, including land, water (including quantity and timing of delivery), money, or restrictions on the use of those resources, without the consent of the permittee, provided the HCP is being properly implemented.[61] If the status of a species addressed under an HCP unexpectedly declines, the primary obligation for undertaking additional conservation measures rests with the federal government, other government agencies, or other non-federal landowners who have not yet developed HCPs. As explained by the federal fish and wildlife agencies:

> Once an HCP permit has been issued and its terms and conditions are being fully complied with, the permittee may remain secure regarding the agreed upon cost of conservation and mitigation. If the status of a species addressed under an HCP unexpectedly worsens because of unforeseen circumstances, the primary obligation for implementing additional conservation measures would be the responsibility of the Federal government, other government agencies, and other non-Federal landowners who have not yet developed an HCP.[62]

However, NMFS may, in the event of unforeseen circumstances, require additional measures provided they are limited to modifications within conserved habitat areas or to the conservation plan’s operating conservation program for the affected species, and that these measures do not involve additional financial commitments or resource restrictions without the consent of the permittee. These assurances are provided to all HCP permittees that properly implement their plans.

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[61] 63 Fed. Reg. 8859 (Feb. 23, 1998).

[62] *Id*. at 8868. The No Surprises rule was promulgated jointly by the Department of the Interior (Service) and the Department of Commerce (National Marine Fisheries Service).

6.5.2 Changed Circumstances

This section of the HCP addresses future changed circumstances affecting the Covered Species. Federal regulations define the concepts of "changed and unforeseen circumstances" and set forth the parameters of the Permittee's potential responsibilities in response to such changed and unforeseen circumstances.

Generally, a "changed circumstance" is a change in the circumstances affecting a Covered Species that can be reasonably anticipated, which allows a plan to be developed in advance to respond to the change. Changed Circumstances are defined under the Federal "No Surprises" rule as changes in circumstances affecting a species or geographic area covered by a conservation plan that can reasonably be anticipated by plan developers and NMFS and that can be planned for (e.g., the listing of a new species, or a fire or other natural catastrophic event in areas prone to such events).

Changed circumstances typically include unplanned but relatively predictable events, such as fires, flooding, and other natural occurrences like an invasion of pests or non-native plants. Anticipating and addressing changed circumstances adds to the conservation value of the HCP by reducing the potential risks to the Covered Species associated with the changed circumstance. This approach also provides NMFS with additional assurance that the Permittee will take certain actions if such changed circumstances occur, while providing the Permittee with assurance that its future responsibilities are defined and not open-ended.

6.5.2.1 Changed Circumstances Provided for in this HCP

The following Changed Circumstances can reasonably be anticipated to occur throughout the Plan Area during the term of the Plan:

- Climate Change
- Drought
- Fire
- Flood
- New Listings of Species not Covered by the Plan

Each of the defined Changed Circumstances includes a description of the Changed Circumstance and a summary of planned responses to be undertaken in the case of such Changed Circumstances. The City and NMFS agree that the Changed Circumstances defined by this section of the Plan represent all Changed Circumstances to be addressed by the City. Planned responses will not include any actions beyond those expressly identified in this section, nor for any event not specifically identified as a Changed Circumstance.

Climate Change

During the implementation period for the Plan, the Plan Area will undergo a change in climatic conditions. The signs of global climate change continue to mount and include melting glaciers, heat waves, rising seas, flowers blooming earlier, lakes freezing later, and migratory birds delaying their flights south. The World Meteorological Organization stated that "[t]he decade 2001–2010 was also the warmest on record. Temperatures over the decade averaged 0.46°C above the 1961–1990 mean, 0.21°C warmer than the previous record decade 1991–2000. In turn, 1991–2000 was warmer than previous decades, consistent with a long-term warming trend." (World Meteorological Organization (WMO) 2010). The California Energy Commission's Public Interest Energy Research Program reports that climate change will have significant societal impacts, including effects on the water supply, flood risk, levee vulnerability, air quality, agriculture, and human health (Bonfils et al. 2007). In addition to societal impacts, California's vulnerability to climate change and its associated changes in temperature and precipitation will affect natural ecosystems (Mastrandrea et al. 2009).

The effects of climate change on the Covered Species and communities can be difficult to predict as they will be influenced by a number of indirect effects and species interactions but NMFS has determined that freshwater streams important to salmonids may experience increased frequencies of floods, droughts, lower summer flows and higher temperatures as a result of climate change (NMFS 2016b). In particular, the potential effects of climate change on fog frequency along the central coast may have important implications for the Covered Species, as fog provides approximately one-third of the water received by coastal ecosystems. Increases in air temperature could be exacerbated by continuation of a trend of 33% reduction in the frequency of summer fog in coastal California (Johnstone and Dawson 2010). But the predictions for future summer fog frequency on California's central coast are unclear. While a 33% reduction in the frequency of California summer fog has been observed over the past century (Johnstone and Dawson 2010), the predicted increase in temperature differential between coastal and inland areas may increase the frequency of summer fog, thereby offsetting the effects of climate change on temperatures in coastal areas. Despite the uncertainty regarding the role of fog, it is possible that the annual average maximum temperature for the Plan Area could increase by 4-5° F during the term of the Plan (Langridge 2018).

Analysis of climate change trends indicate that in California average air temperatures, rising sea levels, changes in precipitation, and change in the frequency and/or severity of extreme events such as heat waves, droughts, and catastrophic fires are all expected as a result of climate change (NMFS 2016b). Overall, climate change can reasonably be expected to influence the ecological response of Covered Species over the term of the Plan. However, the specific type and magnitude of these changes is uncertain. Nonetheless, for the Covered Species climate change will present enormous challenges. All California native anadromous fishes have been rated as “highly or critically vulnerable” to climate change. Increasing air temperatures have the potential to limit the quality and availability of summer rearing habitat for juvenile coho by increasing water temperatures. The range of surface water temperatures are likely to shift, resulting in higher high temperatures as well as higher low temperatures in streams. These higher low stream temperatures have a variety of impacts on juvenile salmonids, including the potential to limit the quality and availability of summer rearing habitat (NMFS 2012b). Increases in summer temperatures will lead to thermal stress, decreased growth, and adverse effects on the survival of out-migrating juveniles. There may also be shifts in migration timing and contraction of species range – a recent bioclimatic analysis of major fish distributions predicts significant range contractions and local extinctions at the southern portion of the California Current System (Cheung et al. 2015).

Climate change will be considered a Changed Circumstance if the annual average maximum air temperature increases by 4° F compared to 2018 during the term of the Plan.

Planned Response to Climate Change

Under the Plan, actions to help address the effects of climate change will be a consideration in the selection of NFCF projects through the TAC, and actions to address the effects of climate change will also be taken through the adaptive management program in response to information obtained from the monitoring program. In addition, in the event of a changed circumstance, the City will develop additional response actions funded by the insurance fund, if deemed appropriate in coordination with NMFS. Given the global scale of climate change, it is expected that numerous federal, state, and local agencies would be responding to the circumstance. The City would look to climate adaptation strategies developed by NMFS to address the Covered Species and would coordinate with NMFS and other agencies to ensure that City-funded responses complement the response actions of those agencies.

While the direct effects of climate change on ecosystems and species within the Plan Area are difficult to quantify at this time, it is clear that climate change has the potential to increase the frequency and severity of the other Changed Circumstances addressed by the Plan (e.g., drought, fire, and flood).

Drought

The 2012-2015 prolonged drought in central coastal California likely foreshadows future conditions in the Plan Area. Anticipated warming air temperatures will make the combination of dry and warm years more likely, increasing the negative impacts of drought (Diffenbaugh et al. 2015). Drought conditions limit water availability and stress various salmonid life stages and overall ecosystem health.

Drought can also lead to an increased incidence of wildfire (Langridge 2018; Chartrand 2018). These reductions in precipitation will likely decrease streamflows during spring and summer which result in reduced availability of flows that support smolt migration to the ocean and reduced availability of summer rearing habitat (NMFS 2012b).

Drought is defined as under the Plan as a climatic drought extending beyond a three-year period. The occurrence of a drought extending beyond three years will be considered a changed circumstance.

Planned Response to Drought

The conservation strategy specifies fish flows for specific water year types, thereby anticipating climatic variability and the possibility of an increase in dry and critically dry years during the term of the Plan. The prescribed flows for dry and critically dry years were designed to be protective of the Covered Species during those water year types. In addition, the City will respond to extended drought conditions through the adaptive management program based on input from the monitoring program. In the event of a drought extending beyond three years, adaptive management responses would be augmented through responses funded by the Changed Circumstances insurance fund.

Fire

The frequency, intensity, and magnitude of wildfires are expected to increase in California (Luers et al. 2006; Westerling and Bryant 2006). It is “highly likely” that the Central Coast will continue to see large severe fires (Langridge 2018), including “megafires.” The National Interagency Fire Center defines “megafire” as a fire that burns more than 100,000 acres.

Fires in riparian areas can result in canopy cover loss and increased water temperature in streams sensitive to heating. Fires also increase the incidence of erosion by removing vegetative cover from steep slopes. Subsequent rainstorms can produce destructive debris flows that bury habitat in tons of sediment and block passage.

Under the Plan, the occurrence of a megafire or a fire that occurs in the same location as previous fires that have occurred within the prior 5 years constitute a changed circumstance.

Planned Response to Fire

In the event of a fire, the HCP Administrator will assess the proportion of the Plan Area that burned and its likely effects on habitat used by the Covered Species and will make an initial determination of whether or not a Changed Circumstance exists. The HCP Administrator will notify NMFS and coordinate with NMFS and other agencies regarding a response to the fire event, if warranted. If a

Changed Circumstance is determined to exist, the HCP Administrator will implement a post-fire monitoring plan for a two-year period. If the monitoring indicates that vegetation is not recovering sufficiently in burned riparian areas to reestablish the pre-fire functions of the affected habitat, the HCP Administrator will develop and implement a habitat restoration plan to enhance recovery of the affected habitat area. Actions in the restoration plan could include stabilizing soils, reestablishing native vegetation, and controlling invasive plant species.

Flood

Under climate change scenarios, precipitation will take the form of increased rain instead of snow, and the intensity of rain events is expected to increase. In general, wet years will be wetter, and dry years will be drier (Chartrand 2018). The projected increases in precipitation intensity during storms may result in destructive debris flows in areas recently burned, resulting in adverse conditions for salmonids by covering habitat with mud and debris, blocking passage, and affecting water quality. Winter flooding during storm runoff events may also reduce the early life stage survival rates for anadromous salmon.

Floods that are greater than 50-year and up to and including 100-year levels, as classified by the Federal Emergency Management Agency (FEMA), constitute a Changed Circumstance under the Plan.

Planned Response to Flood

Responses to floods in the Plan Area would first include responses taken through the adaptive management program, augmented in circumstances where a Changed Circumstance has occurred through additional responses utilizing the Changed Circumstances insurance funding. Response actions could include clearing out sediment and debris to restore or improve passage conditions. City responses would be coordinated with NMFS.

New Listings of Species not Covered by the Plan

NMFS or USFWS may list additional species as threatened or endangered under the ESA that occur in the Plan Area or add new species listings that are not Covered Species. In the event that a species not covered by the HCP is listed, the provisions of this Changed Circumstance will be automatically triggered.

Planned Response to New Species Listing

Upon a new listing of a species under federal endangered species laws, the City will undertake the following measures:

- Evaluate the potential impacts of Covered Activities on the newly listed species and conduct an assessment of the presence of suitable habitat in areas of potential effect.
- Implement measures to avoid impacts to the newly listed species until such time as the Plan has been amended to include the newly listed species as a covered species.

In the event that a species not covered by the Plan becomes listed as threatened or endangered or designated as a candidate species, or is proposed or petitioned for listing, the City may request that NMFS add the species to the relevant take authorizations issued pursuant to the Plan. In determining whether to seek take coverage for the species, the City will consider, among other things, whether the species is present in the Plan Area, if the Covered Activities could result in the take of the species, and if the existing conservation measures benefit the species and avoid and minimize effects of covered activities on the species. The procedures for Plan modifications and amendments are described in Section 6.6.4 Formal Amendment.

6.5.3 Unforeseen Circumstances

NMFS defines unforeseen circumstances as those changes in circumstances that affect a species or geographic area covered by an HCP that could not reasonably have been anticipated by the Plan participants during the development of the conservation Plan, and that result in a substantial and adverse change in the status of a Covered Species.[63] Under ESA regulations, if unforeseen circumstances arise during the life of the Plan, NMFS may not require the commitment of additional land or financial compensation, or additional restrictions on the use of land, water, or other natural resources other than those agreed to in the Plan, unless the Permittees consent.

Within these constraints, NMFS may require additional measures, but only if: (1) the agency demonstrates that an unforeseen circumstance exists; (2) such measures are limited to modifications of the Plan's operating conservation program for the affected species; (3) the original terms of the Plan are maintained to the maximum extent practicable; and (4) the overall cost of implementing the Plan is not increased by the modification. NMFS bears the burden of demonstrating that unforeseen circumstances exist. A finding of unforeseen circumstances must be clearly documented, based upon the best available scientific and commercial information and made considering certain specific factors.[64] If such a finding is made and additional measures are required, the City will work with NMFS to appropriately redirect resources to address the unforeseen circumstances.

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[63] 50 C.F.R. §222.102.

[64] These factors include the following: (1) Size of the current range of the affected species; (2) Percentage of range adversely affected by the conservation plan; (3) Percentage of range conserved by the conservation plan; (4) Ecological

6.5.4 Applicability of Other Endangered Species Act Issues to the Plan

6.5.4.1 Future Section 7 Consultations

NMFS will evaluate the direct, indirect and cumulative effects of the Covered Activities in its internal biological opinion that will be issued in connection with the Plan and issuance of the section 10(a) permits and the biological opinion that will be issued to the City. Accordingly, in any consultation under Section 7 that occurs after the approval of the Plan, NMFS will ensure that any biological opinion issued in connection with the proposed project that is the subject of the consultation is consistent with the Plan biological opinion. The proposed project must be consistent with the terms and conditions of the Plan. Unless otherwise required by law or regulation, any reasonable and prudent measures included under the terms and conditions of a biological opinion issued subsequent to the approval of the Plan with regard to the Covered Species and Covered Activities will, to the maximum extent appropriate, be consistent with the measures of the Plan. The No Surprises Rule will apply to instances in which measures are imposed in excess of those that have been or will be required by the City pursuant to the Plan.

6.6 Permit Duration and Renewal, Plan Amendments, Permit Suspension and Revocation

6.6.1 Permit Duration

The City is seeking take authorization from NMFS with a term of 30 years. The term of the take authorizations issued under the Plan would begin from the date of their issuance. A permit term of 30 years provides a practicable timeframe in which to carry out the activities that will be authorized under the Plan.

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significance of that portion of the range affected by the conservation plan; (5) Level of knowledge about the affected species and the degree of specificity of the species' conservation program under the conservation plan; and (6) Whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild. 50 C.F.R. §222.307(g)(3)(iii).

6.6.2 Plan Administrative Actions that do not Require Modification or Amendment

The administration and implementation of the Plan will require frequent and ongoing interpretation of the provisions of the Plan. Actions taken on the basis of these interpretations that do not substantively change the purpose or intent of the Plan provisions will not require modification or amendment of the Plan or its associated authorizations. Such actions related to the ordinary administration and implementation of the Plan may include, but are not limited to, the following:

- Clerical corrections to typographical, grammatical, and similar editing errors that do not change the intended meaning or to maps or other exhibits to address insignificant errors;
- Adaptive management changes to conservation measures, including actions to avoid, minimize, and mitigate impacts;
- Adjustments to monitoring protocols to incorporate new protocols approved by NMFS.

6.6.3 Minor Modifications or Revisions

As part of the process of Plan implementation, the City may need to make minor changes (“Minor Modifications or Revisions”) to the Plan from time to time to respond appropriately to new information, scientific understanding, technological advances, and other such circumstances. Minor Modifications or Revisions will, in many instances, be technical in nature and will not involve changes that would adversely affect Covered Species, the level of take, or the obligations of the City.

6.6.3.1 Procedures for Minor Modifications or Revisions

The City may propose Minor Modifications or Revisions by providing written notice to NMFS. Such notice will include a description of the proposed Minor Modifications or Revisions, an explanation of the reason for the proposed Minor Modifications or Revisions, an analysis of its environmental effects including any impacts to Covered Species, and an explanation of why the City believes the effects of the proposed Minor Modifications or Revisions would not:

- Significantly differ from, and would be biologically equivalent to, the effects described in the Plan, as originally adopted;
- Conflict with the terms and conditions of the Plan, as originally adopted; and
- Significantly impair implementation of the Plan Conservation Strategy.

NMFS may submit comments on the proposed Minor Modification or Revision in writing within sixty (60) days of receipt of notice. If NMFS does not concur that the proposed Minor Modification or Revision meets the requirements for a Minor Modification or Revision, the proposal must be approved according to the Amendment process. If the City and NMFS concur that the requirements for a Minor Modification or Revision have been met and the modification or revision should be incorporated in the Plan, the Plan will be modified accordingly.

6.6.4 Formal Amendment

Under some circumstances, it may be necessary to substantially amend the Plan. Any proposed changes to the Plan that do not qualify for treatment under Section 6.6.3 will require Formal Amendment. Formal Amendment to the Plan will also require corresponding amendment to the Permit, in accordance with applicable laws and regulations regarding permit amendments. The City will be responsible for submitting any proposed Amendments to NMFS.

Amendments to the Plan will likely occur infrequently. The process for making Formal Amendments is set forth in Section 6.6.4.1 below. Formal Amendments include, but are not limited to, the following:

- Substantive changes to the boundary of the Plan Area;
- Additions of species to the Covered Species list;
- Substantial changes in covered activities that would have effects on the Covered Species outside of the range established in the Plan;

6.6.4.1 Process for Formal Amendment

The Permit may be amended in accordance with all applicable legal requirements, including but not limited to the ESA, NEPA, and NMFS' permit regulations. The Party proposing the amendment shall provide a statement of the reasons for the amendment and an analysis of its environmental effects, including its effects on operations under the Plan and on Covered Species.

6.6.5 Suspension of the Permit

Under certain circumstances defined by federal regulation, NMFS may suspend, in whole or in part, the regulatory authorizations they issue under the Plan. However, except where NMFS determines that emergency action is necessary to avoid irreparable harm to a Covered Species, it will not suspend an authorization without first (1) attempting to resolve the issue through the informal dispute resolution process set forth in Section 6.6.8, and (2) identifying the facts or action/inaction which may warrant the suspension and providing the City a reasonable opportunity to implement appropriate responsive actions.

6.6.6 Reinstatement of Suspended Permit

If NMFS suspends the Permit, as soon as possible but no later than 10 days after the suspension, it will meet and confer with the City to discuss how the Permit can be reinstated. At the conclusion of the meeting, NMFS will identify reasonable, specific actions needed to address the suspension. Upon performance or completion of the actions, NMFS will immediately reinstate the Permit. It is the expectation of the Plan participants that NMFS and the City will strive to reinstate the Permit as soon as possible.

6.6.7 Revocation of the Permit

Unless immediate revocation is necessary to avoid the likelihood of jeopardy to a listed species, NMFS will not revoke the Permit unless the City fails to fulfill its obligations under the Plan, and only after (1) completing the informal dispute resolution process described in Section 6.6.8, and (2) identifying the actions/inactions that may warrant the revocation and giving the City a reasonable opportunity to implement appropriate responsive actions.

6.6.8 Dispute Resolution

The City and NMFS (Party or collectively Parties) recognize that disputes concerning implementation of, compliance with, or termination of the Plan, and the Permit may arise from time to time. The Parties agree to work together in good faith to resolve such disputes, using the informal dispute resolution procedures set forth in this section, or such other procedures upon which the Parties may later agree. However, if at any time any Party determines that circumstances so warrant, it may seek any available remedy without waiting to complete informal dispute resolution.

6.6.8.1 Informal Dispute Resolution Process

Unless the Parties agree upon another dispute resolution process, or unless an aggrieved Party has initiated administrative proceedings or suit in federal court as provided in this section, the Parties may use the following process to attempt to resolve disputes:

(a) The aggrieved Party will notify the other Parties of the provision that may have been violated, the basis for contending that a violation has occurred, and the remedies it proposes to correct the alleged violation.

(b) The Party alleged to be in violation will have 30 days, or such other time as may be agreed, to respond. During this time, it may seek clarification of the information provided in the initial notice. The aggrieved Party will use its best efforts to provide any information then available to it that may be responsive to such inquiries.

(c) Within 30 days after such response was provided or was due, representatives of the Parties having authority to resolve the dispute will meet and negotiate in good faith toward a solution satisfactory to all Parties, or will establish a specific process and timetable to seek such a solution.

(d) If any issues cannot be resolved through such negotiations, the Parties will consider non-binding mediation and other alternative dispute resolution processes and, if a dispute resolution process is agreed upon, will make good faith efforts to resolve all remaining issues through that process.

7.0 COSTS AND FUNDING

7.1 Financial Summary

The City’s HCP involves four programs to be funded by the City:

1) Habitat Conservation Program (Section 7.2.1);
2) Monitoring Program (Section 7.2.2);
3) Adaptive Management program (Section 7.2.3); and,
4) Program Administration (Section 7.2.4).

The habitat conservation strategy described in this chapter includes a suite of potential NFCF measures to be implemented in the Santa Cruz Mountains Ecoregion. These measures focus on key independent and dependent watersheds in southern San Mateo County south to Aptos Creek in Santa Cruz County. Additionally, a Take Avoidance and Minimization Fund (TAMF) will be instituted for measures related to operations and maintenance and Capital Improvement Program (CIP) related habitat conservation measures. Chapter 6 describes the compliance, effectiveness, and research monitoring programs.

The adaptive management program, also described in Chapter 6, includes provisions to select, fund, and implement additional measures if the measures described in Chapter 4 do not achieve the expected biological results. Program administration is described in Section 7.2.4 of this chapter. The total 30-year estimated cost of this HCP is $ 36,674,500 in 2018 dollars. Figure 7-1 and Figure 7-2 show how the forecasted HCP costs are spread over the 30-year term. The total cost for each of the four program areas and their respective subcategories is provided in Table 7-1. Additional detail is provided later in this chapter.

Table 7-1: Habitat Conservation Plan Financial Summary

Program	Estimated Cost (2018 dollars)
Habitat Conservation (see Table 7- 2) NFCF TAMF[65]	 $ 8,000,000 *$ 157,400,000*
Monitoring (see Table 7- 4 & Table 7-5) Compliance Effectiveness Research	$18,377,500
Adaptive Management (see Table 7-6) Contingency Account Insurance Account	 $ 1,600,000 $ 2,640,000
Administration (see Section 7.2.4)	$ 6,057,000
TOTAL COST	**$36,674,500[66]**

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[65] TAMF costs include supplemental water supply development, Majors, Laguna, Tait Street and Felton Diversions rehabilitation, treatment improvements, construction best practices implementation and related take avoidance and minimization measures.

[66] TAMF costs are not included in the analysis of HCP implementation funding because many of the projects associated with those costs have independent utility.

7.2 Program Costs

7.2.1 Habitat Conservation Programs Costs

The estimated habitat conservation program costs are primarily associated with NFCF habitat conservation measures. TAMF costs are not included in the analysis of HCP implementation funding because many of the projects associated with those costs have independent utility in that they are necessary for future water system reliability but also have conservation benefit in most cases. Nonetheless, the total cost is shown here to provide context. Totals are provided in Table 7-2 below.

Table 7-2: Habitat Conservation Programs Estimated Costs

Habitat Conservation Program Measure Category	Estimated Cost in 2018 Dollars (30-year total)
NFCF	$8,000,000
TAMF	$157,400,000
TOTAL COSTS	**$165,400,000**[67]

TAMF - related operations and maintenance costs are mainly associated with staff time and therefore are also not included in this analysis. TAMF related CIP costs include measures such as supplemental water supply development, Felton Diversion fish screen improvements, North Coast Diversion sediment management improvements, operational and infrastructure improvements as well as standard best practices for protection of natural resources employed during operations and maintenance of the water system. These improvements and system rehabilitation are not entirely precipitated by this HCP; however, significant system-wide improvements are required for a variety of reasons and have independent utility, with regard to water operations beyond compliance with the ESA. This improvements and rehabilitation work will, in many cases, require mitigation of impacts caused by historical operations. While these improvements have not been fully evaluated to the extent that firm budget estimates are possible, it is likely that their costs will be in the range of $100-150 million dollars (2018 dollars) and be implemented within the first 10 years of issuance of the HCP. Most TAMF costs are associated with implementation of these projects.

Habitat Conservation Program Measures

Table 4-9, as previously discussed in Section 4.5.3, provides a clear linkage between residual impacts and potential mitigation projects presented through the ecological portfolios. Table 4-9 also associates

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[67] TAMF costs are not included in the analysis of HCP implementation funding.

each of the potential portfolio projects with an estimated cost in 2018 dollars. Based on this two-phase process of linking impacts to projects in a portfolio and developing costs for projects in the portfolio, the level of funding required for the NFCF can be quantified.

Once the ecological portfolios have been completed and this hybrid quantitative-qualitative metric has been translated into dollars, the final step is to develop a cost allocation plan for implementation of the NFCF. The costs allocation plan is a 30-year budget for the NFCF that is divided into six 5-year planning cycles with associated work plans. The allocation is further divided into annual expenditures. The cost allocation plan is presented in 2018 dollars and provides a snapshot of annual funding as well as a realistic view of what can be accomplished with the NFCF funding currently recommended. The cost allocation is included in Table 7.3. See also Appendix 1: *Summary of Approach to Non-Flow Mitigation of Biological Effects of the City Diversions*. Most of the planning, permitting, and project management for these measures will be done by 1.0 new full-time equivalent Water Department staff, and related costs are included in the staff time subtotal shown in Table 7-3.

If measures are not implemented as planned and substitute measures are implemented (per the Adaptive Management Programs described in Chapter 6), the funding will come from the amounts allocated to the original measures (with inflation if implemented at a later date).

If NFCF projects require minor maintenance, such as replanting or invasive plant removal, costs will be paid from the 20% contingency funds in the Adaptive Management Program – as approved in consultation with the TAC. Five-year funding increments for the NFCF are described further in Table 7-3 below.

Table 7-3: Estimated NFCF Habitat Conservation Measure Costs[68]

Fiscal Year	Task	Amount (In Fiscal Year 2019 dollars)
HCP Years 1 - 5	Develop 5 yr. project list	$ 55,000
	Project 1 Permit	$ 15,000
	Project 1 Design	$ 60,000
	Project 1 Construction	$ 15,000
	Project 1 Implementation	$ 200,000
	Project 2 & 3 Permit	$ 35,000
	Project 2 Design	$ 70,000
	Project 3 Design	$ 65,000
	Project 2 & 3 Construction	$ 70,000
	Project 2 & 3 Implementation	$ 350,000
	Project 4 Permit	$ 20,000
	Project 4 Design	$ 60,000
	Project 4 Construction	$ 15,000
	Project 4 Implementation	$ 270,000
	Project 5 Permit	$ 65,000
	Project 5 Design	$ 100,000
	HCP Years 1 - 5 Subtotal	**$ 1,465,000**
HCP Years 6 - 10	5 yr. NFMP Review	$ 30,000
	Develop 5 yr. project list	$ 20,000
	Project 9 Design	$ 60,000
	Project 5 Implementation	$ 500,000
	Project 6 Permit	$ 15,000
	Project 6 Design	$ 60,000
	Project 6 Construction	$ 15,000
	Project 6 Implementation	$ 200,000
	Project 7 & 8 Permit	$ 30,000
	Project 7 Design	$ 60,000
	Project 8 Design	$ 75,000
	Project 7 Construction	$ 20,000
	Project 8 Construction	$ 20,000
	Project 7 Implementation	$ 200,000
	HCP Years 6 - 10 Subtotal	**$ 1,305,000**
HCP Years 11 - 15	Develop 5 yr. project list	$ 55,000
	Project 8 Implementation	$ 275,000
	Project 9 Permit	$ 20,000
	Project 9 Design	$ 10,000
	Project 9 Implementation	$ 220,000
	Project 9 Construction	$ 15,000
	Project 10 & 11 Permit	$ 25,000
	Project 10 Design	$ 65,000

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[68] Specific habitat conservation measure priorities have not been identified or committed to. However, support for coho recovery hatchery development and operations is a high priority.

	Project 11 Design	$ 70,000
	Project 10 & 11 Construction	$ 20,000
	Project 10 & 11 Implementation	$ 300,000
	Project 12 Permit	$ 55,000
	Project 12 Design	$ 125,000
	Project 12 Construction	$ 25,000
	Project 13 Design	$ 60,000
	HCP Years 11 - 15 Subtotal	**$ 1,340,000**
HCP Years 16 - 20	5 yr. NFMP Review	$ 30,000
	Develop 5 yr. project list	$ 20,000
	Project 12 Implementation	$ 475,000
	Project 13 Permit	$ 20,000
	Project 13 Construction	$ 15,000
	Project 13 Implementation	$ 220,000
	Project 14 Permit	$ 20,000
	Project 14 Design	$ 50,000
	Project 14 Construction	$ 15,000
	Project 14 Implementation	$ 220,000
	Project 15 & 16 Permit	$ 25,000
	Project 15 Design	$ 60,000
	Project 16 Design	$ 70,000
	Project 17 Permit	$ 20,000
	Project 17 Design	$ 120,000
	HCP Years 16 - 20 Subtotal	**$ 1,380,000**
HCP Years 21 - 25	5 yr. NFMP Review	$ 30,000
	Develop 5 yr. project list	$ 30,000
	Project 15 & 16 Construction	$ 20,000
	Project 15 & 16 Implementation	$ 250,000
	Project 17 Permit	$ 50,000
	Project 17 Construction	$ 20,000
	Project 17 Implementation	$ 500,000
	Project 18 & 19 Permit	$ 25,000
	Project 18 & 19 Construction	$ 15,000
	Project 18 & 19 Implementation	$ 275,000
	Project 18 Design	$ 60,000
	Project 19 Design	$ 70,000
	Project 20 Design	$ 30,000
	HCP Years 21 - 25 Subtotal	**$ 1,375,000**
HCP Years 26 - 30	5 yr. NFMP Review	$ 30,000
	Project 22 Implementation	$ 450,000
	Project 20 & 21 Permit	$ 30,000
	Project 20 & 21 Construction	$ 15,000
	Project 20 & 21 Implementation	$ 250,000
	Project 20 Design	$ 40,000
	Project 21 Design	$ 70,000
	Project 22 Permit	$ 75,000

	Project 22 Design	$ 120,000
	Project 22 Construction	$ 25,000
	Final Project Review	$ 30,000
	HCP Years 26 - 30 Subtotal	**$ 1,135,000**
Total Cost		**$ 8,000,000**

7.2.2 Monitoring Programs Estimated Costs

Costs for the monitoring program are shown in Table 7-4. The monitoring activities included are described in Chapter 6.

Table 7-4: Monitoring Programs Estimated Costs

Monitoring Measure Category	**Estimated Cost in 2018 Dollars (30-year total)**
Compliance	$ 3,000,000
Effectiveness	$ 800,000
Research	$ 14,577,500
$18,377,500	$18,377,500

7.2.2.1 Research Program Estimated Costs

The estimated costs to implement the research measures described in Chapter 6 are shown in Table 7-5. Some of these dollar amounts are part of larger partnership programs (see details in Chapter 6). The City has committed to a research monitoring program that is significantly broader in scope than many comparable HCPs.

Table 7-5: Research Monitoring Estimated Costs

Monitoring Measure	**Estimated Cost in 2018 Dollars (30-year total)**
Riverine Juvenile Abundance and Spatial Distribution Monitoring	$4,033,500
Estuarine Juvenile Abundance	$ 3,000,000
Riverine Habitat Monitoring	$ 330,000
Estuarine Habitat Monitoring	$ 1,674,000
Felton Diversion Adult Migration Monitoring	$ 310,0000
Temperature Monitoring	$ 420,000
Pit Tag Monitoring	$ 410,000
Reporting and Equipment	$ 660,000
Data Management	$ 950,000
TOTAL COST	**$ 14,577,500**

7.2.3 Adaptive Management Programs Estimated Costs

Costs involved in the Adaptive Management Program include:

1) Unanticipated maintenance needs of NFCF projects;
2) Responses to monitoring of measures if effectiveness monitoring indicates original measures have not met their stated objectives;
3) Responses to assessments of the overall effectiveness of the HCP; and,
4) Changes in research monitoring priorities and methodologies that would exceed the cost estimate in Table 7-5.

Elements of the adaptive management programs are described in Chapter 6. Actual future costs associated with adaptive management are dependent on information not yet available. (See Program Funding - Section 7.3 below for total dollars allocated). The adaptive management funding allocations are shown in Table 7-6 and total $4,240,000 over 30 years. These amounts are capped totals (with inflation adjustment), except as affected by provisions of Section 6.5, Changed and Unforeseen Circumstances. To fund the planned responses to address changed circumstances, an “insurance account” will be established concurrent with HCP adoption as a component of the adaptive management funding. A total of $2,640,000 will be deposited into the insurance account over 30 years (Table 7-6 insurance account).

7.2.4 Administration Program Estimated Costs

Costs associated with program administration include staffing for overall implementation of the HCP including indirect costs for support of all HCP activities.

The indirect cost for implementation of the HCP is comprised of 15% of the fully loaded ongoing salary costs for monitoring, data management, and compliance reporting, as well as the fully loaded cost of the salary plus 15% indirect costs of 1.0 new full time equivalent (FTE) position for implementation of the NFCF.

The overall administration costs of the HCP are approximately $6,057,000.

7.3 Program Funding

The City will pay the costs of the HCP from water rate revenues. Each spring, the City Council adopts an annual budget for the Water Department based on anticipated costs and revenues. The annual budget is a public document and is available on the City’s web site. Commitments made in the HCP will be included in the annual budget requests to the Council. Although the City Council will not automatically fund these expenses, adoption of the HCP demonstrates the City’s commitment to fund and implement it. Further, the City understands that permit coverage would be at risk, and federal and state enforcement measures would be possible, if adequate budgets are not approved and measures are not implemented as planned.

City Constraints Associated with Funding

The City recognizes that changes in the allocation of funds from one project or action to another might be necessary during the 30-year term of the HCP. Reallocation decisions will be made by the City, but will take into account advice given by the HCP TAC. To allow flexibility, the City will accommodate reallocation of funds within the following constraints:

- The total funding must adhere to the schedule in Figure 7-1.
- The annual increments of funding must adhere to the schedule in Figure 7-2.
- Funds can be reallocated within programs and categories, but not between programs and categories; some category totals are capped.

Details of these constraints are described in the sections below.

Scheduled Funding Increments

The City has carefully spread HCP investments over the 30-year timeframe to achieve habitat conservation benefits, to accommodate adaptive management contingencies, and to manage the impact on water ratepayers. The total funding allocated for the life of the permit by category is shown in Figure 7-1, while annual increments of investment by category are shown in Figure 7-2. The City's analysis has shown that shifting funds forward or backward in time from the defined increments will have unacceptable effects on water rates. For this reason, the funding allocations are confined to the time periods shown. Shifts in the allocation of project costs can occur only within, not between, the allocated time periods.

Limits on City's Financial Commitments

The City's total financial commitments to all elements of this HCP are capped at the totals previously shown in Table 7-1. These capped amounts will be inflation-adjusted (see Section 7.4). Details are provided in Section 7.3.1.

Figure 7-1: Total Habitat Conservation Plan Funding by Program Area in 2018 Dollars

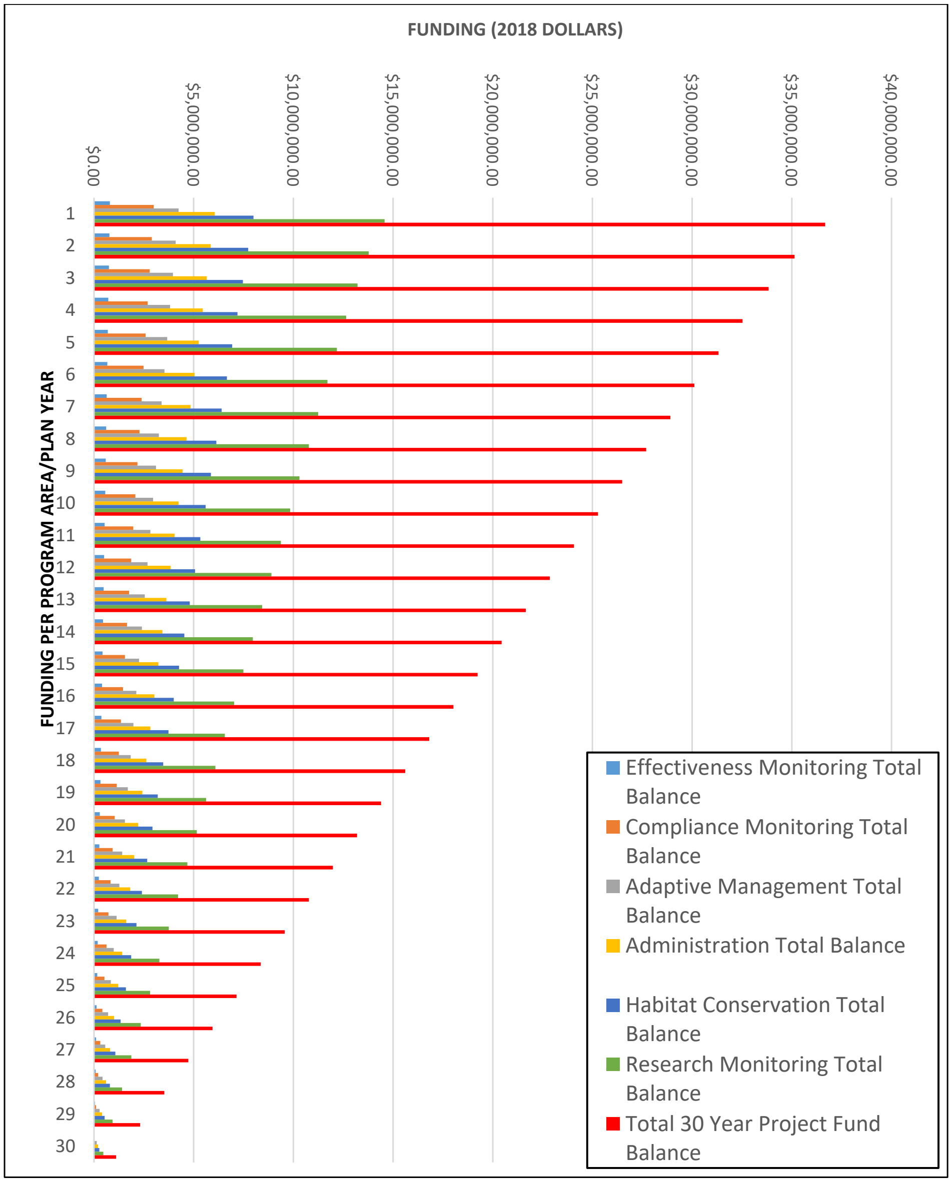
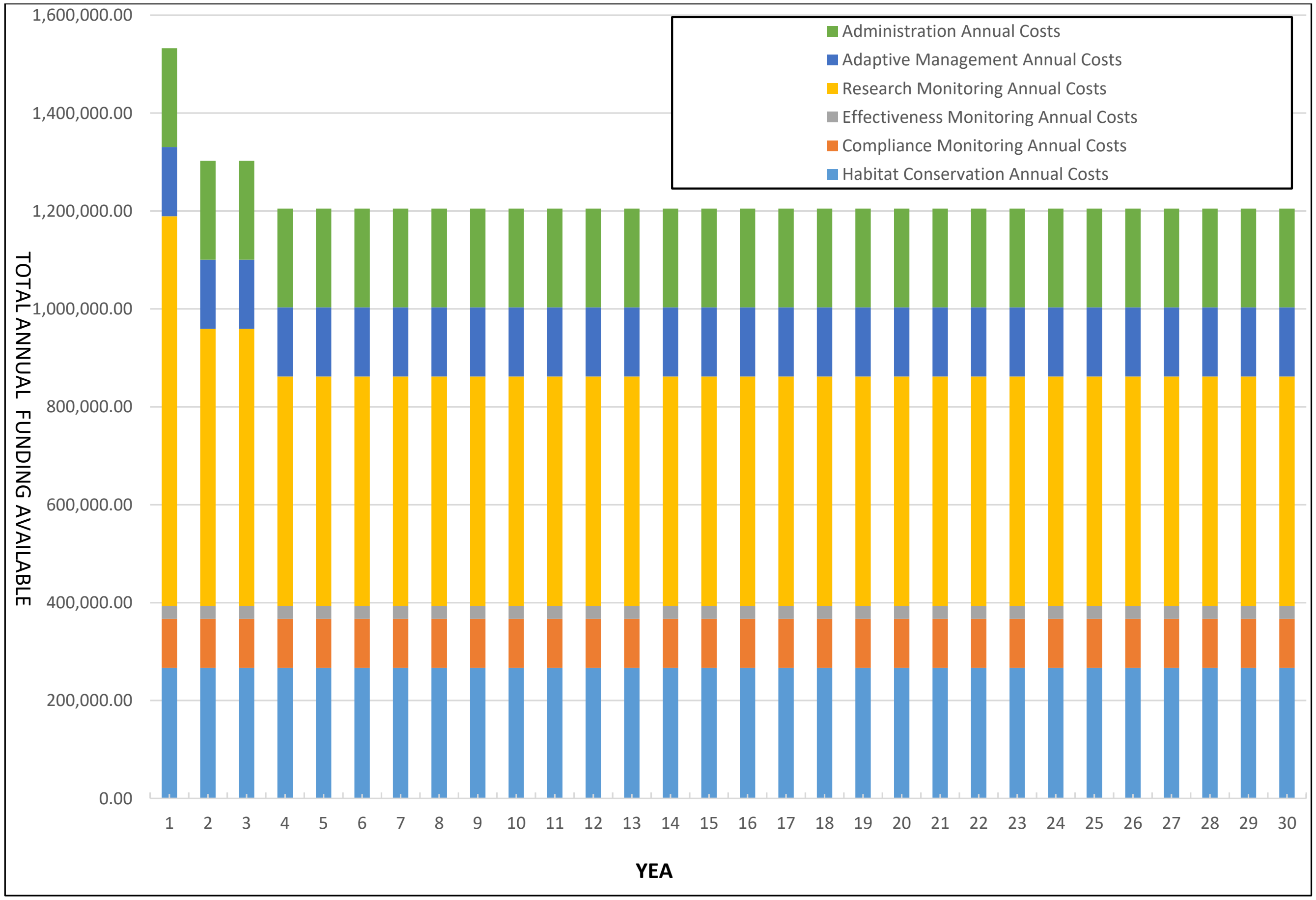


Figure 7-2: Total Annual Funding Committed to Non-Flow Conservation Fund Program/Adaptive Management and Insurance Fund in 2018 Dollars



7.3.1 Habitat Conservation Programs Funding

The City has allocated $8 million[69] to the NFCF. Funding will be available in the scheduled increments as shown in Figure 7-1 and Figure 7-2. The amounts shown in Table 7-3 are the estimated cost of each habitat conservation measure, not including a 20 percent contingency allowance. The City will pay up to the amount shown in Table 7-4 for each measure plus additional costs accounting for inflation by utilizing the national implicit price deflator (deflator) up to the date of implementation. The deflator measure is used to apply the effects of inflation for state and local government expenditures according to the California Department of Finance.[70] For example, the funding for a measure implemented in 2025 would be inflated from the 2018 estimate to 2025 based on the total rate of inflation between these periods as measured by the deflator. The deflator inflated amount represents the financial limit of the City's commitments for each project.

Annual spending on design, permitting and implementation is expected to average approximately $275,000 per year (in 2018 dollars) within each 5-yr planning cycle over the 30-year lifetime of the HCP. The City may, at its discretion, choose to allocate the total funding for the program equally throughout the 30-year Permit term as depicted in Figure 7-2 or front-load funding in the early years of the Plan.

The City is confident the dollar amounts allocated will be adequate to meet the measurable objectives described in Chapter 4. If, however, after detailed project planning, the measure is shown to cost more than the amount shown in Table 7-3 (inflated to the implementation date), the City will consult with the TAC about how to proceed. A variety of options are possible, including the following:

- The extra cost, above the amount shown in Table 7-3 plus the deflator rate of inflation, could be paid with savings from NFCF habitat measures that cost less than expected.
- The extra cost, above the amount shown in Table 7-3 plus deflator rate of inflation, could be deducted from remaining unallocated dollars in the NFCF.
- An alternative funding source could be found to supplement City funding for the project.
- A lower-cost measure with similar habitat benefits could be identified and implemented.

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[69] The NFCF analysis presented in Appendix 1 estimated a range of approximately $8,011,479 to $8,250,000 specifically for habitat conservation spending over the permit term. $8 million is used for simplicity's sake in this discussion and future planning purposes.

[70] Economic Research Unit, "How to Use CPI Data" State of California Department of Finance, Economic Research Unit, 2018, http://www.dof.ca.gov/Forecasting/Economics/Documents/How_to_Use_CPI_Data.pdf .

- The scope of the project could be modified.

The City will not pay for expenses that exceed the per-project totals shown in Table 7-3 (as inflated to implementation date), except as provided in the Adaptive Management Program or in Chapter 6, Changed and Unforeseen Circumstances. The scheduling of the offsite measures is also constrained by the availability of the funding increments shown in Table 7-3.

If needed, effectiveness monitoring for NFCF projects will be paid from the total allocated to the NFCF if funds are available there. Concurrent with adoption of the HCP, the City will establish a "contingency account" and over the 30-year term will deposit a $1.6 million subset of the Adaptive Management Program funding into the contingency account to cover unanticipated costs of NFCF projects and related effectiveness monitoring. In addition, a $2.64 million subset of the Adaptive Management Program funding will be deposited into a separate "insurance account" specifically set aside for adaptive management and changed circumstances responses in accordance with the schedule in Figure 7-2. If needed, research monitoring can be funded from this insurance account as well. If the $2.64 million is not needed for adaptive management or changed circumstances responses, it will remain available to fund additional habitat conservation measures through the NFCF.

7.3.2 Monitoring Programs Funding

The City will fund the monitoring programs as shown in Table 7-4. The amounts defined in Table 7-4 are capped totals. The City will accommodate reallocation of funds within the categories shown in the table, but will not pay more than the totals shown for each category, as adjusted for inflation unless needed for adaptive management purposes (see Section 7.2 and Section7.4).

7.3.3 Adaptive Management Programs Funding

The adaptive management funding allocations are shown in Table 7-6. These amounts are capped totals (with inflation adjustment, see Section 7.4), except as affected by provisions of Section 6.5, Changed and Unforeseen Circumstances.

As mentioned above, up to $1.6 million representing a 20% contingency of the NFCF as well as the insurance account of $2.64 million are available for adaptive management and changed circumstances responses, according to the framework described in Chapter 6 and shown in Figure 7-1 and Figure 7-2. If needed, research monitoring can be funded from the $2.64 million insurance account and effectiveness monitoring can be funded by the $1.6 million contingency account. If the funds in the contingency account are not needed for adaptive management or changed circumstances at the milestones described in Chapter 6 and shown in Figure 7-2, they will remain available to fund additional habitat conservation measures through the NFCF .

The adaptive management funding allocations are shown in Table 7-6. These amounts are capped totals (with inflation adjustment, see Section 7.4), except as affected by provisions of Section 6.5, Changed and Unforeseen Circumstances.

Table 7-6: Adaptive Management Program Funding Allocations

Adaptive Management Programs Funding Category	Allocation in 2018 Dollars (30-year total)
NFCF Contingency Account	$1,600,000
Insurance Account	$2,640,000
TOTAL COST	**$4,240,000**

7.3.4 Jump Start and Stay Ahead Provision

To jump start non-flow conservation actions, the City will implement funding for year 1 projects in fiscal year 2024. Subsequent to permit issuance, the City will implement funding of year 2 projects, monitoring, adaptive management and administrative costs. This is anticipated to occur in fiscal year 2025. Future years’ funding will be allocated similarly. Conservation flows will be implemented upon permit issuance. After implementation of these flows, residual effects to steelhead and coho habitat will be relatively minor. As such, early implementation of projects with FY 2024 and FY 2025 funding will more than fully offset impacts to coho and steelhead during the initial phases of HCP implementation. Subsequent implementation of NFCF projects in accordance with the schedule set out in Table 7-3 over the 30-year term will ensure that mitigation stays well ahead of impacts from Covered Activities.

7.4 Adjustments for Inflation or Deflation

All cost estimates and commitments in the HCP are shown in 2018 dollars. These dollar commitments will be adjusted annually for inflation or deflation using the historical deflator rates of change for state and local governments published by the U.S. Department of Commerce, which measures price changes in goods and services purchased by government programs on behalf of consumers. Deflators are not available below the national level so regional modifications are not possible.

8.0 ALTERNATIVES

8.1 No-action Alternative

Under the No Action Alternative, a section 10(a)(1)(B) permit would not be issued. City activities with the potential to cause incidental take of listed species would require measures to avoid incidental take or individual incidental take authorizations on a project-by-project basis, as is currently the case. Incidental take authorizations for activities with the potential to incidentally take listed species would be obtained either through the section 7 consultation process or through the development of individual HCPs.

Under this approach, few of the conservation and economic benefits associated with the HCP would be realized. The HCP establishes uniform conservation measures to ensure that biological goals and objectives for the Covered Species will be met and that opportunities to ensure the long-term survival of Covered Species are maximized.

Under the No Action alternative, many of the regulatory efficiencies provided by the HCP would not be available to the City. Rather, the City would continue to engage in the time-consuming process of reaching agreement with NMFS on the conditions under which activities that may affect listed species may proceed. Through this process, project mitigation requirements may vary from project to project, adding uncertainty and confusion over regulatory obligations. In contrast, the HCP would provide the City with long-term predictability concerning the nature of its operations and activities for which incidental take is permitted, avoiding cumbersome procedures and potential delays that would compromise the operation and maintenance of City facilities.

8.2 Reduced Covered Activities Alternative

Under a reduced covered activities alternative, the City would limit the HCP to bypass flows, and the numerous activities associated with operations and maintenance of the water supply system would not be covered. As with the No Action Alternative, under this alternative the City would need to evaluate individual operations and maintenance activities to determine whether incidental take of listed species could be avoided through seasonal restrictions and other modifications to the activity, or whether an activity-specific incidental take authorization would instead be required.

When determined to be required, project-by-project incidental take authorizations would be sought through the Section 7 consultation process or through a project-specific Section 10 permit application. In contrast to a comprehensive HCP, project-by-project incidental take authorizations would tend to result in small piecemeal mitigation that can be more expensive and time-consuming and provide less conservation benefit than a regional or watershed level approach. Such authorizations can also result in inconsistent and changing minimization measures that complicate implementation of operations and maintenance activities.

Processing individual applications for numerous operations and maintenance activities would also require a substantial expenditure of resources by the City and NMFS over the years and would require NMFS to balance competing priorities from other entities and projects. This could interfere with timely implementation of operations and maintenance activities that are critical to providing a safe and reliable water supply. Accordingly, this alternative was not selected.

9.0 LIST OF PREPARERS

The following professional staff contributed to the preparation of this HCP:

City of Santa Cruz Water Department
- Chris Berry - Watershed Compliance Manager

Ebbin Moser + Skaggs LLP
- Sean Skaggs – Principal

Hagar Environmental Science
- Jeff Hagar – Principal

Gary Fiske and Associates
- Gary Fiske - President

Balance Hydrologics, Inc.
- Shawn Chartrand, PhD, CEG – Principal Geomorphologist

Alnus Ecological
- Jim Robins – Principal and Senior Ecologist

10.0 REFERENCES

2NDNATURE. 2006. Comparative Lagoon Ecological Assessment Project (CLEAP) Santa Cruz County, California. Client: Santa Cruz County Resource Conservation District. Funder: California Coastal Conservancy. October 2006. Draft Final Report.

2NDNATURE. 2008. Laguna Creek Lagoon 2007 Monitoring Summary. Prepared for City of Santa Cruz. March 2008.

2NDNATURE. 2009a. 2008 San Lorenzo River Lagoon Annual Water Quality Progress Report. Prepared for County of Santa Cruz Environmental Health Department. February 10, 2009

2NDNATURE. 2009b. 2008 Laguna Lagoon Annual Water Quality Progress Report. Prepared for City of Santa Cruz. April 24, 2009

2NDNATURE. 2009c. 2008 Laguna Lagoon Annual Water Quality Progress Report, Final Report. Submitted to the City of Santa Cruz Water Department. April 24.

2NDNATURE. 2010a. 2009 Laguna Lagoon Annual Water Quality Progress Report, Final Report. Submitted to the City of Santa Cruz Water Department. March 30.

2NDNATURE. 2010b. 2009 San Lorenzo River Lagoon Annual Water Quality Progress Report, Final Report. Submitted to the City of Santa Cruz. March 30.

2NDNATURE. 2011. 2010 San Lorenzo and Laguna Lagoon Annual Water Quality Progress Report, Final Report. Submitted to the City of Santa Cruz Water Department. April 15.

2NDNATURE. 2012. 2011 San Lorenzo and Laguna Lagoon Annual Water Quality Progress Report, Final Report. Submitted to the City of Santa Cruz Water Department. May 21.

2NDNATURE. 2013. San Lorenzo and Laguna Lagoon Annual Water Quality 2012, Annual Report. Submitted to the City of Santa Cruz Water Department. May 2013.

2NDNATURE. 2014. San Lorenzo and Laguna Lagoon Annual Water Quality 2013, Annual Report - Final Draft. Submitted to the City of Santa Cruz Water Department. June 2014.

2NDNATURE. 2015. San Lorenzo and Laguna Lagoon Annual Water Quality 2014, Annual Report - Final Report. Submitted to the City of Santa Cruz Water Department. June 2015.

2NDNATURE. 2016. San Lorenzo and Laguna Lagoon 2015 Water Quality Summary, Annual Report – Final Report. Submitted to the City of Santa Cruz Water Department. June 2016.

2NDNATURE and HES. 2016. San Lorenzo River Lagoon water quality and fish analysis. Technical Memorandum prepared for the City of Santa Cruz Water Department. January 2016.

2NDNATURE. 2018. San Lorenzo & Laguna Lagoon 2017 Water Quality Summary Santa Cruz California. Submitted to the City of Santa Cruz Water Department. Annual Report, Final, June 2018.

2NDNATURE. 2019. San Lorenzo & Laguna Lagoon 2018 Water Quality Summary Santa Cruz California. Submitted to the City of Santa Cruz Water Department. Annual Report, Final, June 2019.

Adams, P.B.; Boydstun, L.B.; Gallagher, S.P.; Lacy, M.K.; McDonald, T.; Shaffer, K.E. 2011. California coastal salmonid population monitoring: strategy, design, and methods. Fish Bulletin 180. California Department of Fish and Game. 82 p.

Agrawal, A., R. S. Schick, E. P. Bjorkstedt, R. G. Szerlong, M. N. Goslin, B. C. Spence, T. H. Williams, K. M. Burnett. 2005. Predicting the Potential for Historical Coho, Chinook, and Steelhead Habitat in Northern California. NOAA-TM-NMFS-SWFSC-379 U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Southwest Fisheries Science Center.

Alley, D.W. 1995. Comparison of Juvenile Steelhead Densities in 1981 and 1994 With Estimates of Total Numbers of Mainstem Juveniles and Expected Numbers of Adults Returning to the San Lorenzo River, Soquel Creek and Corralitos Creek, Santa Cruz County, California. Prepared for City of Santa Cruz Water Department, City of Watsonville Water Department, Lompico County Water District, San Lorenzo Valley Water District and Soquel Creek Water District by D.W. ALLEY &Associates.

Alley, D.W. 1995b. Comparison of Juvenile Steelhead in 1981, 1994 and 1995 with an Estimate of Juvenile Population Size in the Mainstem San Lorenzo River, With Expected Numbers of Adults Returning from Juveniles Reared in the Mainstem River, Santa Cruz County, California. Prepared for the City of Santa Cruz Water Department and the San Lorenzo Valley Water District by D.W.ALLEY & Associates.

Alley, D.W. 1996. Baseline Monitoring of Steelhead and Water Quality in Carbonera Creek for the Scotts Valley Water District Pilot Program of Groundwater Recharge, Santa Cruz County, California,1995. Prepared for the Scotts Valley Water District by D.W. ALLEY & Associates.

Alley, D.W. 1997. Comparison of Juvenile Steelhead in 1981, and 1994-96, with an Estimate of Juvenile Population Size in the Mainstem San Lorenzo River and Expected Numbers of Adults Returning from that Production, Santa Cruz County, California. Prepared for the City of Santa Cruz Water Department and the San Lorenzo Valley Water District by D.W. ALLEY & Associates.

Alley, D.W. 1998. Comparison of Juvenile Steelhead Densities in 1981 and 1994-97 in the San Lorenzo River and Tributaries, Santa Cruz County, California; With an Estimate of Juvenile Population Size in the Mainstem River and Expected Adult Returns. Prepared for the City of Santa Cruz Water Department, Santa Cruz County Environmental Planning Department and the San Lorenzo Valley Water District by D.W. ALLEY & Associates.

Alley, D.W. 1999. Comparisons of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions for the San Lorenzo River, Santa Cruz County, California, 1994-1998; with Predicted Adult Returns. Prepared for the City of Santa Cruz Water Department, Santa Cruz County Environmental Planning Department and the San Lorenzo Valley Water District by D.W. ALLEY& Associates.

Alley, D.W. 2000. Comparisons of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions for the San Lorenzo River, Santa Cruz County, California, 1995-1999; with an Index of Adult Returns. Prepared for the City of Santa Cruz Water Department, Santa Cruz County Environmental Planning Department and the San Lorenzo Valley Water District by D.W. ALLEY& Associates.

Alley, D.W. 2001a. Comparisons of Juvenile Steelhead Densities, 1996 through 2000, in the San Lorenzo River and Tributaries, Santa Cruz County, California; with an Index of Adult Returns.

Prepared for the City of Santa Cruz Water Department, Santa Cruz County Environmental Planning Department and the San Lorenzo Valle y Water District by D.W. ALLEY & Associates.

Alley, D.W. 2001b. Comparison of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions for Soquel Creek, Santa Cruz County, California; 1997-2000; with an Index of Adult Returns. Prepared by D.W. ALLEY & Associates for the Soquel Creek Water District.

Alley, D.W. 2015. Appendix B. Detailed Analysis of 2015 Steelhead Monitoring in the San Lorenzo, Soquel, Aptos, and Corralitos Watersheds. 2015 Santa Cruz County Fishery Report.

Alley, D.W., J. Dvorsky, J. Ricker, K. Schroeder, J. Smith. 2004. San Lorenzo River Salmonid Enhancement Plan, Fisheries Enhancement Strategy for the San Lorenzo River. Submitted to Santa Cruz County Environmental Health Services. March 2004.

Anderson, K.R. 1995. A status review of the coho salmon (*Oncorhynchus kisutch*) in California south of San Francisco Bay. Report to the Fish and Game Commission, California Department of Fish and Game, Region 3, Monterey.

Armour, C.L. 1991. Guidance for Evaluating and Recommending Temperature Regimes to Protect Fish. Instream Flow Information Paper 28. U.S. Fish and Wildlife Service, Fort Collins, Colorado. Biological Report 90(22) December 1991.

Balance Hydrologics. 1998. Assessment of streambed conditions and erosion control efforts in the San Lorenzo River watershed, Late 1970s to 1996. Report for Santa Cruz County.

Barnhart, R. A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildlife Serv. Biol. Rep. 82(11.60), 21 p.

Beck, M.W., K. Kittleson, and K. O'Connor. Analysis of the Juvenile Steelhead and Stream Habitat Database, Santa Cruz County, California. Web Products and Recommendations. Southern California Coastal Water Research Project. July 2019. Technical Report 1082.

Berry, C. 2016. Subject: City of Santa Cruz Anadromous Salmonid Habitat Conservation Plan Felton Diversion Downstream Passage Issues – December 2016. City of Santa Cruz, Water Department.

Berry, C., Bean, E., Bassett, R., Martinez-McKinney, J., Retford, N., Chirco-MacDonald, D., and Hagar, J. 2019. North Coast Anadromous Creeks Snorkel Fish Counts and Habitat Survey Data Summary 2018. Prepared for the City of Santa Cruz Water Department. Santa Cruz, CA.

Bidgood, B.F., and A.H. Berst. 1969. Lethal temperatures for Great Lakes rainbow trout. J. Fish. Res. Bd. Canada 16: 456-459

Biotic Resources Group. 2002. City-wide Creeks and Wetlands Management Plan. Prepared for the City of Santa Cruz Department of Planning and Community Development.

Bjornn, T. C. and Reiser, D. W. 1991. Habitat Requirements of Salmonids in Streams. In *Influences of Rangeland Management on Salmonid Fishes and Their Habitats* (Meehan), Ed., American Fisheries Society, Bethesda, MD.

Bond, M.H. 2006. Importance of Estuarine Rearing to Central California Steelhead (*Oncorhynchus mykiss*) Growth and Marine Survival. MA thesis, University of California, Santa Cruz.

Bonfils, C., P. Duffy, B. Santer, T. M. L. Wigley, D.B. Lobell, T. J. Phillips, and C. Doutriaux. 2007. Identification of External Influences on Temperatures in California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-047.

Borcalli and Associates. 2001. Felton Diversion Fish Screen Evaluation. Prepared for Entrix, Inc. Prepared by Borcalli and Associates, Inc Consulting Engineers. Sacramento, California.

Boughton, David A. 2010. Estimating the Size of Steelhead Runs by Tagging Juveniles and Monitoring Migrants. North American Journal of Fisheries Management 30(1): 89–101. http://www.tandfonline.com/doi/abs/10.1577/M09-046.1.

Bovee, K.D. 1978. Probability-of-use criteria for the family *Salmonidae*. Instream Flow Information Paper No. 4. Cooperative Instream Flow Service Group, U.S. fish & Wildlife Service, Fort Collins, CO.

Bovee, K.D. B.L. Lamb, J.M. Bartholow, C.B. Stalnaker, J. Taylor, and J. Henriksen. 1998. Stream habitat analysis using the instream flow incremental methodology. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD-1998-0004. viii + 131 pp.

Brabb, et al. (Compiled by.) 1997. Geologic Map of Santa Cruz County, California: A Digital Database. Digital database prepared by S. Graham, C. Wentworth, D. Knifong, R. Graymer and J. Blissenbach. http://wrgis.wr.usgs.gov/openfile/of97-489 .

Brabb, E. E., S. Graham, C. Wentworth, D. Knifong, R. Graymer, and J. Blissenbach. 1997. Geologic Map of Santa Cruz County, California: A Digital Database. Website: http://wrgis.wr.usgs.gov/open-file/of 97-489.html .

Brock, T.C. 1985. A eutrophic lake: Lake Mendota, Wisconsin. Springer.

Brown, R.L., P.B. Moyle, and R. M. Yoshima. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management 14: 237261.

Bryant, G.J. 1994. Status review of coho salmon populations in Scott and Waddell Creeks, Santa Cruz County, California. National Marine Fisheries Service, Southwest Region, Protected Species Management Division, Santa Rosa, CA. April 1994, 104 p.

Buller, T.W. 2006. Technical Memorandum - Evaluation of and Recommendation for Improvements to Santa Cruz Water Department's San Lorenzo River-Felton Diversion Facility. Prepared by Wood Rogers, Sacramento, California.

Burgi, H. and P. Stadelmann. 2002. Change of phytoplankton composition and biodiversity in Lake Sempach before and during restoration. *Hydrobiologia*, 469:33-48.

Busby, P. J., Wainwright T. C., Bryant, G. J., Lierheimer, L. J., Waples, R. S., Waknitz, F. W. & Lagomarsino, I. V. 1996. Status Review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA. NMFS-NWFSC-27. 261 pp.

Camp, Dresser, & McKee, Inc. 1996. San Lorenzo.Valley and North Coast Watersheds, Sanitary Survey Final Report. Consulting report prepared for City of Santa Cruz Water Department, San Lorenzo Valley Water District, and other water purveyors.

Cannata, S.P. 1998. Observations of Steelhead trout (*Oncorhynchus mykiss*), Coho Salmon (*O. kisutch*) and Water Quality of the Navarro River Estuary Lagoon May 1996 to December 1997. Humboldt State University Foundation, April 20, 1998.

CDFW. 1971. Agreement Between City of Santa Cruz and State of California Department of Fish and Wildlife for Streamflow Maintenance and Operation of Fishway at Felton Diversion Project on San Lorenzo River for the Protection and Preservation of the Fish and Wildlife Resources. Prepared for the State of California Resources Agency. Sacramento, California.

CDFW. 1997a. Stream Inventory Report – Zayante Creek, California Department of Fish and Game.

CDFW. 1997b. Stream Habitat Survey Data from Mountain Charlie Gulch. Survey Data obtained from J. Nelson, California Department of Fish and Game, Aptos Ca.

CDFW. 2000. Exhibit A Department of Fish and Game Fish Screening Criteria June 19, 2000. http://www.fgc.ca.gov/regulations/2008/749_3EXHIBIT%20A.pdf

CDFW. 2012. Standard Operating Procedure for Critical Riffle Analysis for Fish Passage in California. California Department of Fish and Game Instream Flow Program Standard Operating Procedure DFG-IFP-001. 24 p. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=57462

California Department of Water Resources. 1958. Sedimentation studies—Zayante and Bean Creeks, Tributaries of the San Lorenzo River, Santa Cruz County, Project No 58-3-4. Report for Central Coast Regional Water Quality Control Board.

Chartrand, S. 2018. Review of CMIP5 Climate Change Hydrology Projections for the City of Santa Cruz Habitat Conservation Plan. Memo dated June 28, 2018.

Cheung W. W. L., Frölicher T. L., Asch R. G., Jones M. C., Pinsky M. L., Reygondeau K. B., Rodgers K. B., Rykaczewski R. R. et al. 2015. Building confidence in projections of the responses of living marine resources to climate change. ICES Journal of Marine Science, 73: 1283 –1296.

City of Santa Cruz. 2010. City of Santa Cruz Activities Description – Endangered Species Act Section 10 Permit. August 20, 2010.

City of Santa Cruz Water Department. 2005. Use of Copper to Control Aquatic Weeds in Loch Lomond Reservoir. California Environmental Quality Act Initial Study and Mitigated Negative Declaration. March 25, 2005.

County of Santa Cruz. 2001. Draft San Lorenzo River Watershed Management Plan Update. County of Santa Cruz Water Resources Program, Environmental Health Services and Planning Department. December 2001.

County of Santa Cruz. 2019. TMDL Report for the San Lorenzo River, Soquel Creek, and Aptos Creek Watersheds. October 2019.

D.W. Alley & Associates. 2005. Comparison of Juvenile Steelhead Densities, 1997-2001 and 2003-2004, In the Middle and Upper San Lorenzo River and 4 Tributaries, Santa Cruz County, California; With an Estimate of Juvenile Population Size and an Index of Adult Returns. Prepared for San Lorenzo Valley Water District. March 2005. Project # 200-02.

D.W. Alley and Associates. 2007. 2006 Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos, and Corralitios Watersheds, Santa Cruz County, California. Prepared for the Santa Cruz County Environmental Health Department. May 2007.

D.W. ALLEY & Associates. 2009. 2008 Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds, Santa Cruz County, California, With Trend Analysis of the San Lorenzo and Soquel Watersheds, 1997-2008 −DRAFT REPORT. Prepared for the Santa Cruz County Environmental Health Department Government Center, 701 Ocean Street, Room 312, Santa Cruz, CA 95060.

D.W. ALLEY & Associates. 2016. 2015 Summary Report - Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds, Santa Cruz County, California. Appendix B. Detailed Analysis of 2015 Steelhead Monitoring in the San Lorenzo, Soquel, Aptos, and Corralitos Watersheds. Prepared for the Santa Cruz County Environmental Health Department Government Center, 701 Ocean Street, Room 312, Santa Cruz, CA 95060. Project # 200-12a

Diffenbaugh, Noah S., Daniel L. Swain, and Danielle Touma. 2015. “Anthropogenic Warming Has Increased Drought Risk in California.” Proceedings of the National Academy of Sciences of the United States of America 112 (13). National Academy of Sciences: 3931–36. doi:10.1073/pnas.1422385112.

Dunham, J., G. Chandler, B. Rieman, D. Martin. 2005. Measuring stream temperature with digital data loggers: a user's guide. Gen. Tech. Rep. RMRS-GTR-150WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

East, Amy & Stevens, Andrew & Ritchie, Andrew & Barnard, Patrick & Campbell-Swarzenski, Pamela & Collins, Brian & Conaway, Christopher. (2018). A regime shift in sediment export from a coastal watershed during a record wet winter, California: Implications for landscape response to hydroclimatic extremes: Sediment flux regime shift. Earth Surface Processes and Landforms. 43. 10.1002/esp.4415.

ENTRIX, Inc. 1997. Operational Changes at Felton Diversion to Improve Fish Passage. Prepared for City of Santa Cruz Water Department. August 27,1997.

ENTRIX, Inc. 2002. Steelhead, Red-Legged Frog, and Western Pond Turtle Habitat Surveys in Laguna and Majors Creeks. Prepared for City of Santa Cruz Water Department.

ENTRIX, Inc. 2004a. Final Appendix B, Aquatic Resources Report, City of Santa Cruz Section 10 Program. July 12, 2004.

ENTRIX, Inc. 2004b. Final Appendix B, Physical Resources Report, City of Santa Cruz Section 10 Program. July 12, 2004.

Environmental Sciences Associates. 2001. Coast Dairies Long-Term Resource Protection and Use Plan, Existing Conditions Report. San Francisco, CA.

Environmental Sciences Associates. 2018. San Lorenzo System Design Modification – Project Description. Memorandum to Stephanie Strelow (Dudek). July 6, 2018.

Flossi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California Salmonid Stream Habitat Restoration Manual. California Department of Fish and Game. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=22610&inline

Food and Agriculture Organization. 2002. Fish Passes Design, Dimensions, and Monitoring. Food and Agriculture Organization of the United Nations Deutscher Verband für Wasserwirtschaft und Kulturbau e.V. (DVWK) Rome, 2002

Fulton, L.A., H.A. Gangmark, and S.H. Bair. 1953. Trial of Denil Type Fish Ladder on Pacific Salmon. United States Department of Interior Fish and Wildlife Service, Special Scientific Report: Fisheries No. 99.

H.T. Harvey and Associates. 2003a. Salmonid Monitoring in the San Lorenzo River, 2002. Prepared for City of Santa Cruz, Water Department. April 2, 2003.

H.T. Harvey & Associates. 2003b. San Lorenzo River Lagoon Steelhead Monitoring Feasibility Study. Prepared by H.T. Harvey & Associates and Scott Cressey. Prepared for: City of Santa Cruz. February 18, 2003.

Griggs, G. 2012. Santa Cruz Main Beach, Coastal Processes, and the Historic Course of the San Lorenzo River Mouth. Prepared for City of Santa Cruz. Gary Griggs, Consulting Coastal Geologist. October 2012.

Hagar, J.M. 2005. Field notes from reconnaissance survey of Liddell Creek on December 16, 2005.

Hagar, J.M. 2014. Ramping Rates to Protect Salmonid Habitat in City of Santa Cruz Source Streams. Technical Memo prepared for Chris Berry, City of Santa Cruz Water Department. Prepared by Hagar Environmental Science, Richmond, California. September 29, 2014.

Hagar, J. E. Bean, and C. Berry, 2017a. North Coast Streams Limit of Anadromy. Prepared for City of Santa Cruz Water Department. August 23, 2017.

Hagar, J. E. Bean, and C. Berry, 2017b. Newell Creek Limit of Anadromy. Prepared for City of Santa Cruz Water Department. August 23, 2017.

Hagar Environmental Science (HES). 2002. Carmel River Lagoon Breach Monitoring Report 2001-2002. Prepared for: Monterey County Water Resources Agency. May 31, 2002.

HES. 2003a. Carmel River Lagoon and Salinas River Lagoon Breach Monitoring Report, 2002-2003. Prepared for: Monterey County Water Resources Agency. July 2, 2003.

HES. 2003b. Branciforte Creek Flood Control Channel Maintenance Project Steelhead Population Abundance Estimate. Prepared for: City of Santa Cruz Public Works Administration. September 22, 2003.

HES, 2005a. Draft Mountain Charlie Gulch Steelhead Assessment Survey. Prepared for City of Santa Cruz. January 28, 2005. 21 p.

HES. 2005b. DRAFT CLEAP Fish Sampling in San Lorenzo and Laguna Creek Lagoons 2004. Prepared for: California Coastal Conservancy and Santa Cruz County. February 9, 2005.

HES. 2005c. Mount Hermon Summer Dam Improvement Project Fish Removal Activities. Technical Memorandum Prepared for: Mount Hermon Association, Inc., Mount Hermon, California. J-142. November 8, 2005.

HES. 2007. Newell Creek Habitat and Fish Population Survey 2007. Technical Memorandum Prepared for: Ebbin Moser + Skaggs LLP. J-133. December 13, 2007.

HES. 2009a. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling. Technical Memorandum, January 5, 2009.

HES. 2009b. Assessment of Streamflow Effects on Migration, Spawning, and Rearing Habitat for Anadromous Salmonids in Streams Influenced by City Diversions.

HES. 2010. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling. Technical Memorandum, January 15, 2010.

HES. 2011a. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2010. Technical Memorandum, September 30, 2011.

HES. 2011b. Electrofishing Calibration of Visual Abundance Estimates of Rearing Steelhead in North Santa Cruz County Streams. Prepared for City of Santa Cruz Water Department. March 7, 2011. 8 p.

HES. 2012. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2011. Technical Memorandum, December 11, 2012.

HES. 2013. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2012. Technical Memorandum, November 15, 2013.

HES. 2014a. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2013. Technical Memorandum, June 24, 2014.

HES. 2014b. Assessment of Stream flow Effects on Migration, Spawning, and Rearing Habitat for Anadromous Salmonids in Streams Influenced by City of Santa Cruz Water Diversions Including Newell Creek. Prepared for City of Santa Cruz Water Department. Prepared by Hagar Environmental Science, Richmond, California. December 1, 2014.

HES. 2014c. Branciforte Creek Flood Control Channel Maintenance Project Steelhead and Tidewater Goby Surveys 2014. Prepared for the City of Santa Cruz Public Works Administration. Prepared by Hagar Environmental Science, Richmond, California. October 24, 2014.

HES. 2015. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2014. Technical Memorandum, June 25, 2015.

HES. 2016. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2015. Technical Memorandum, June 28, 2016.

HES. 2017. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2016. Technical Memorandum, June 30, 2017.

HES. 2018. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2017. Technical Memorandum, June 29, 2018.

HES. 2019. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2018. Technical Memorandum, June 27, 2019.

HES. 2020. City of Santa Cruz Habitat Conservation Plan, Lagoon Fish Population Sampling 2019. Technical Memorandum, July 2, 2020.

Hall, N. T., A. M. Sarna-Wojcicki, and W. R. Dupre. 1974. Faults and Their Potential Hazards in Santa Cruz County, California. U.S. Geological Survey, Miscellaneous Field Studies Map MF-626.

Hankin, D.G., and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Hart, E. W., and W. A. Bryant. 1997. Fault-Rupture Hazard Zones in California. Special Publication 42. California Department of Conservation, Division of Mines and Geology, Sacramento, California.

Hampton, M. 1988. Development of habitat preference criteria for anadromous salmonids of the Trinity River. United States Fish and Wildlife Service, Division of Ecological Services. Sacramento, California. 93pp.

Hampton, M. 1997. Microhabitat suitability criteria for anadromous salmonids of the Trinity River. U.S. Fish & Wildlife Service, Arcata, CA.

Hardy, T.B. and R.C. Addley. 2001. Evaluation of interim instream flow needs in the Klamath River. Institute for Natural Systems Engineering, Utah Water Research Laboratory, Utah State University, Logan, UT.

Harvey & Stanley Associates, Inc. 1982. Fish Habitat Assessments for Santa Cruz County Streams. Prepared for John Gilchrist & Associates and the Santa Cruz County Planning Department. Preliminary Draft. May 1982.

Hayes, S.A., M. H., Bond, C. V. Hanson, A.W. Jones, A. J. Amman, J. A. Harding, A. L. Collins, J. Perez, and R. B. MacFarlane. 2011. Down, Up, Down and "smolting" twice? Seasonal movement patterns by juvenile steelhead in a coastal watershed with a bar closing estuary. Canadian Journal of Fisheries and Aquatic Sciences 68:1341-1350.

Hecht, B., and Kittleson, G.A. 1998. An assessment of streambed conditions and erosion control efforts in the San Lorenzo River watershed, Santa Cruz County, California: Balance Hydrologics consulting report prepared for Santa Cruz County Environmental Health Division, 77 p.

Herbst, D.B., R.B. Medhurst, S.W. Roberts and J.W. Moore. 2011. Development of Biological Indicators and Targets to Guide Sediment TMDLs for Streams of the Central Coast Region of California and the San Lorenzo River. Final report to the Central Coast Regional Water Quality Control Board.

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 and Yield of Juvenile

Rainbow Trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34: 639-648.

Holley, T. 2010. Analysis of Geomorphological Processes and Changes to Aquatic Habitat for Anadromous Salmonids in Newell Creek, Santa Cruz County, California. NOAA's National Marine Fisheries Service Science and Technology Program Habitat Conservation Division Santa Rosa, CA. June 28, 2010.

Jankovitz, J. and R. Diller. 2019. Summary of Annual Fish Sampling, Water Quality Monitoring, and Active Management; Pescadero Creek Lagoon Complex 2018. California Department of Fish and Wildlife. May 2019.

Johansen, R.R. 1975. State of California Resources Agency Department of Fish and Game. San Lorenzo River (Santa Cruz County) Winter Steelhead and Salmon Fishery, 1971-72 and 1972-73 Seasons.

Johnson, David H. et al. 2007. American Fisheries Society Salmonid Field Protocols Handbook Techniques for Assessing Status and Trends in Salmon and Trout Populations.

Johnstone, J. A., & Dawson, T. E. (2010). Climatic context and ecological implications of summer fog decline in the coast redwood region. Proceedings of The National Academy of Sciences Of The United States Of America, 107(10), 4533-4538. Doi:10.1073/pnas.0915062107.

Jónasson, P.M., E. Lastein, and A. Rebsdorf. 1974. Production, insolation, and nutrient budget of eutrophic lake Esrum. *Oikos*, 25: 255-277.

Jones & Stokes. 2000. City of Santa Cruz Water Supply Alternatives Environmental and Regulatory Constraints Analysis. Prepared for Carollo Engineers, Walnut Creek, CA.

Kawamoto Environmental Services (KES). 2001. Aquatic Assessment and Monitoring Plan for Wilder Ranch State Park. Prepared for State of California Department of Parks and Recreation-Natural Resources Division.

Kennedy Jenks Consultants, Inc. 2018. San Lorenzo River and North Coast Watersheds Sanitary Survey Update. Prepared for the City of Santa Cruz Water Department. Santa Cruz, CA.

Kittleson, K. 2015. County of Santa Cruz Stream Crossing and Fish Passage Evaluation. Prepared by Kristen Kittleson, County of Santa Cruz Fishery Resource Planner.

Langridge, Ruth. (University of California, Santa Cruz). 2018. Central Coast Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-006.

Luers, A. L., D. R. Cayan, G. Franco, M. Hanemann, and B. Croes. 2006. Our changing climate, assessing the risks to California; a summary report from the California Climate Change Center. California Climate Change Center.

Martin, J.A. 1995. Food Habits of some Estuarine Fishes in a Small. Seasonal Central California Lagoon. M.S. Thesis, San Jose State University, Department of Biology. May 1995.

Mastrandrea, M.D., Tebaldi, C., Snyder, C.P., and S.H. Schneider. 2011. Current and Future Impacts of Extreme Events in California. Climatic Change, 109, SI, pp. 43-70.

Maxwell, S.L. and Gove, N.E. 2004. The feasibility of estimating migrating salmon passage rates in turbid rivers using a dual frequency identification sonar (DIDSON), 2002. Regional Information Report No. 2A04-05. Alaska Dept. Fish and Game. Anchorage, AK.

McDonald, T. 2004. GRTS for the Average Joe: A GRTS Sampler for Windows. Biometrics/Statistics Project Report, West Inc., 82001(307): 10.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, E. P. Bjorkstedt. 2000. Viable salmon populations and the recovery of evolutionarily significant units. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-42, 156 p.

McPherson, K.R., L.A. Freeman, and L.E. Flint. 2011. Analysis of Methods to Determine Storage Capacity of, and Sedimentation in, Loch Lomond Reservoir, Santa Cruz County, California, 2009. US Geological Survey Scientific Investigations Report 2011-5141. 88 p.

McCrary, H.T. 2003. Petition to redefine the southern extent of the Central California Coho ESU. (Letter dated 23 November 2003 to R. McInnis, Acting Regional Administrator, NOAA Fisheries, Southwest Region, Long Beach, CA).

McCrary, H.T. 2005. Response to the NOAA Fisheries, Santa Cruz Laboratory's second review of the November 6, 2003 petition from Homer T. McCrary concerning coho salmon south of San Francisco. (Letter dated 10 May 2005 to R. McGinnis, NOAA Fisheries, Southwest Region, Long Beach, CA.).

Montgomery and Associates. 2020. Soquel Creek Monitoring and Adaptive Management Plan (MAMP) Report #6, Oakland, California.

Moyle, P. 2002. Inland Fishes of California, 2nd Edition, Berkeley, University of California Press.

NMFS. 2004. Biological Opinion for the United States Army Corps of Engineers' (Corps) proposed permitting of the City of Santa Cruz Public Works Department to perfrm maintenance and sediment removal within the concrete flood control channel of Branciforte Creek, in the City of Santa Cruz, Santa Cruz County, California (Corps File Number 26875S). United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Region. July 16, 2004. 151422SWR02SR6273:BLS.

NMFS. 2005a. Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. National Marine Fisheries Service. 70 Fed. Reg. 52488 (Sept.2, 2005).

NMFS. 2005b. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. National Oceanic and Atmospheric Administration; Final Rule. 70 Fed. Reg. 37,160 (June 28, 2005).

NMFS. 2006. Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. National Oceanic and Atmospheric Administration; Final Rule. 71 Fed. Reg. 834 (Jan. 5, 2006).

NMFS. 2010. Public Draft Recovery Plan for Central California Coast coho salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

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

NMFS. 2012b. Final Recovery Plan for Central California Coast coho salmon Evolutionarily Significant Unit – Appendix A: Marine and Climate. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

NMFS. 2012c. Endangered and Threatened Species; Range Extension for Endangered Central California Coast Coho Salmon. Final Rule. Federal Register 77 FR 19552.

NMFS. 2016. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS. 2016b. Coastal Multispecies Recovery Plan – Appendix B: Climate Change. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS. 2016c. 2016 5-Year Review: Summary and Evaluation of Central California Coast Coho Salmon. National Marine Fisheries Service. West Coast Region. April 2016.Nolan Associates, 2016. FINAL REPORT Karst Protection Zone Investigation. Prepared for City of Santa Cruz Water Department, Santa Cruz County, California. January 29, 2016.

Phil Williams & Associates. 2004. May 25, 2004 Memorandum Re: Santa Cruz Habitat Conservation Plan. Appendix A-2 to ENTRIX, Inc. Final Appendix B, Aquatic Resources Report, City of Santa Cruz Section 10 Program. July 12, 2004.

Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1984. Habitat Suitability Information: Rainbow trout. U.S. Fish and Wildlife Service FWS/OBS-82/10.60. 64pp.

Regional Water Quality Control Board (RWQCB). 2002. Staff report for regular meeting of September 20, 2002: Adoption of the San Lorenzo River Total Maximum Daily Load for Sediment (including Carbonera Creek, Lompico Creek, and Shingle Mill Creek) as a Basin Plan Amendment. Item 24. Central Coast Region. Pp. 14.

Riemann, B., and M. Søndergaard. 1986. Carbon Dynamics in Eutrophic, Temperate Lakes. Elsevier: New York.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Department of the Environment, Fisheries and Marine Service, Ottawa.

Ricker, J., and T. Butler. 1979. Fishery Habitat and the Aquatic Ecosystem, Technical Section. County of Santa Cruz Community Resources Agency, Watershed Management Section and State of California Resources Agency, Department of Fish and Game, Protected Waterways Program.

Rosenberger, Amanda E., and Jason B. Dunham. 2005. Validation of Abundance Estimates from Mark–recapture and Removal Techniques for Rainbow Trout Captured by Electrofishing in

Small Streams. North American Journal of Fisheries Management 25(4): 1395–1410. http://www.tandfonline.com/doi/abs/10.1577/M04-081.1.

Ross Taylor and Associates, 2004. Final Report: County of Santa Cruz Stream Crossing Inventory and Fish Passage Evaluation. Prepared for County of Santa Cruz Public Works Department. March 2004.

Santa Cruz County. 2008. San Lorenzo wastewater management plan: draft program status report 2002-2007. 1-28.

Santa Cruz County Environmental Health. 2020. Steelhead Monitoring Data Explorer http://scceh.com/steelhead/data.aspx.

SCCWRP. 2021. Juvenile Steelhead and Stream Habitat (JSSH) web. https://sccwrp.shinyapps.io/jssh_web/_w_dbe1b124/_w_cda44c19/_w_9e1e1e9a/_w_9af65b91/_w_ad4ea08c/_w_244b1314/index.Rmd Southern California Coastal Water Research Project.

Shapovalov and Taft. 1954. The Life Histories of the Steelhead Rainbow Trout and Silver Salmon. Department of Fish and Game, Sacramento, CA. Fish Bulletin No. 98.

Smith, J.J. 1982. Fish Habitat Assessments for Santa Cruz county Streams. Prepared for the Santa Cruz County Planning Department.

Smith, J.J. 1990. The Effects of Sandbar Formation and Inflows on Aquatic Habitat and Fish Utilization in Pescadero, San Gregorio, Waddell, and Pomponio Creel Estuary/Lagoon Systems, 1985-1989. Report prepared under Interagency Agreement 84-04-324, between Trustees for California State University and the California Department of Parks and Recreation. 21 December 1990.

Smith, J.J. and H.W. Li. 1983. Energetic factors influencing foraging tactics of juvenile steelhead trout, Salmo gairdneri. In: Predators and Prey in Fishes. Dr. W. Junk Publishers. The Hague. pp. 173-180.

Søndergaard, M., E. Jeppesen, J.P. Jensen, and S.L. Amsinck. 2005. Water framework directive: Ecological classification of Danish lakes. *Journal of Applied Ecology,* 42(4): 616-629.

Spence, B. C., W. G. Duffy, J. C. Garza, B. C. Harvey, S. M. Sogard, L. A. Weitkamp, T. H. Williams, and D. A. Boughton. 2011. Historical occurrence of coho salmon (*Oncorhynchus kisutch*) in streams of the Santa Cruz Mountain region of California: response to an Endangered Species Act petition to delist coho salmon south of San Francisco Bay. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-472.

Strudley, M., Chartrand, S. 2010. Annual Hydrologic Record for Liddell Spring #1 Santa Cruz County, California: Data Report for Water Year 2009. In preparation. Prepared for the City of Santa Cruz Water Department. Santa Cruz, CA.

Swanson Hydrology and Geomorphology (SH&G). 2001a. 2001 Zayante Area Sediment Source Study. Prepared for Santa Cruz County Department of Environmental Health.

Swanson Hydrology and Geomorphology (SH&G). 2001b. Biogeochemical function of the San Lorenzo River Lagoon and Inter-comparison of Central California Coastal Lagoons. Prepared for City of Santa Cruz Water Resources Division.

Swanson Hydrology and Geomorphology (SH&G). 2003. Biogeochemical Function of the San Lorenzo River Lagoon, Santa Cruz, CA, 2002 Season Results. Prepared for the City of Santa Cruz. February 21.

Thompson, K. 1972. Determining stream flows for fish life. Pages 31-50 in Proceedings, instream flow requirements workshop. Pacific Northwest River Basins Commission, Vancouver, Washington.

Titus, R. G., D. C. Erman, and W. M. Snider. History and status of steelhead in California coastal drainages south of San Francisco Bay. In draft for publication as a Department of Fish and Game, Fish Bulletin

Toohey, R.C., Neal, E.G., and Solin, G.L. 2014. Guidelines for the collection of continuous stream water-temperature data in Alaska: U.S. Geological Survey Open-File Report 2014-1182, 34 p., https://dx.doi.org/10.3133/ofr20141182.

U.S. Environmental Protection Agency (EPA). 1976. Quality Criteria for Water.

U.S. Environmental Protection Agency (EPA). 1986. Quality Criteria for Water.

U.S. Environmental Protection Agency (EPA). 2014. Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams. Global Change Research Program, National Center for Environmental Assessment, Washington, DC; EPA/600/R-13/170F. Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea.

USFWS and NMFS. 2016. Habitat Conservation Planning and Incidental Take Permit Processing Handbook. December 21, 2016.

Weitkamp, L.A., Wainwright, T.C., Bryant, G.J., Milner, G.B., Teel, D.J., Kope, R.G., and Waples, R.S. 1995. Status review of coho salmon from Washington, Oregon, and California. U. S. Department of Commerce, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-NWFSC-24: 258 p.

Westerling, A. L. and B. P. Bryant. 2006. Climate Change and Wildfire in and around California: Fire Modeling and Loss Modeling. Prepared for California Climate Change Center. CEC---500---2005---190---SF: 33.

Wetzel, R.G. 2001. Limnology, Lake and River Ecosystems, Third Edition. Academic Press: New York.

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 95060.

World Meteorological Organization. 2010. WMO Statement on the Status of the Global Climate in 2010. Geneva, Switzerland.

Zedonis, P. A. 1992. The Biology of the Juvenile Steelhead (*Oncorhynchus mykiss*) in the Mattole River Estuary/Lagoon. Arcata, CA, M.S. Thesis Humboldt State University: 77.

Personal Communication

Don Alley, personal communication to Chris Berry, 2020

Kathy Bare, SWRCB, personal communication to Chris Berry, 2015

Chris Berry, City of Santa Cruz, personal communication to Kindra Loomis, 2004

Chris Berry, City of Santa Cruz, personal communication to Kindra Loomis, 2004 cited in ENTRIX, Inc. 2004a

Chris Berry, City of Santa Cruz, personal communication to Kindra Loomis, 2004, cited in ENTRIX, Inc. 2004b

Chris Berry, City of Santa Cruz, personal communication to Kindra Loomis, 2004, cited in ENTRIX, Inc. 2004c

Chris Berry, City of Santa Cruz, personal communication to Jeff Hagar 2005

Chris Berry, City of Santa Cruz, personal communication to Jeff Hagar, 2006

Chris Berry, City of Santa Cruz, personal communication to Jeff Hagar, 2014

Chris Berry, City of Santa Cruz, personal communication to Jeff Hagar, 2016

Chris Berry, City of Santa Cruz, personal communication to Jeff Hagar, 2019

Shawn Chartrand, personal communication to Chris Berry, 2019

Shawn Chartrand, personal communication to Chris Berry, 2020

Jon Jankovitz, CDFW, personal communication to Jeff Hagar, 2019

Jon Jankovitz, CDFW, personal communication to Chris Berry, 2020

K. Kittleson, County of Santa Cruz, personal communication to Jeff Hagar, 2020

John Ricker, personal communication to Chris Berry, 2019

Brian Spence, NMFS, personal communication to Chris Berry, 2005

Brian Spence, NMFS, personal communication to Jeff Hagar, 2006