ATTACHMENT 2

DETAILED PROBLEM STATEMENT

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1.0 DETAILED PROBLEM STATEMENT

This detailed problem statement summarizes the historical decline in coho salmon and steelhead in San Gregorio Creek and discusses limiting factors and stressors that have slowed or prevented steelhead and coho recovery in the watershed.

1.1 Declining Fish Populations

Following a review of available information, we conclude that there has been a significant decline in the distribution and abundance of steelhead in San Gregorio Creek and its tributaries since the late 1800s (Stillwater Sciences et al. 2010, Smith 1990, Becker and Reining 2008, Titus et al. 2010, NMFS 2016). In the mid to late 1800s, San Gregorio Creek had sufficient populations of steelhead and coho salmon to support commercial fishing (Commissioners of Fisheries 1872, Skinner 1962). Populations are widely reported to have declined over time, but no estimates of fish populations were made until the 1960s when the 1961-62 steelhead run was estimated to be a few hundred fish with a maximum spawning run size of about 1,000 adults (Becker and Reining 2008, Titus et al. 2010, NMFS 2016). In 1963, the juvenile steelhead population on Alpine Creek was estimated to be about 1,000 fish per 30 meters of stream length (Becker and Reining 2008). A 1973 survey of the same stream estimated an average of 10 to 20 juveniles per pool (Zatkin 2002). In 1985, a stream survey of the San Gregorio Creek main stem described the juvenile steelhead population as moderate to abundant but did not provide estimates of fish numbers (Zatkin 2002). A 2009 fish count estimated 2,500 juveniles in San Gregorio lagoon (Stillwater Sciences et al. 2010). To offset population declines and heavy fishing pressure, San Gregorio Creek was stocked with steelhead as early as 1912 and as recently as 1985 (Titus et al. 2010, Becker and Reining 2008). Current adult populations in the watershed are not known (NMFS 2016).

Steelhead are found in San Gregorio Creek, all of its major tributaries, and in the lagoon. Spawning steelhead enter San Gregorio Creek between late fall and early spring and spawning occurs in two peaks, one in December and another in March and April. Coho salmon historically thrived in the watershed but a viable population has not existed since at least 1976-77 when fish numbers plummeted following a severe drought (Anderson 1995, California Department of Fish and Game[1] (CDFG) 2004, Stillwater Sciences et al. 2010). Small numbers of coho salmon continue to be observed in San Gregorio Creek (Atkinson 2010).

Steelhead in the San Gregorio Creek watershed are listed as threatened under the federal Endangered Species Act. They are not listed under the California Endangered Species Act (ESA). Coho salmon are listed as endangered under both the federal and state ESAs. Consequently, San Gregorio Creek is a priority watershed for coho salmon and steelhead restoration. The California Coastal Commission (CCC) identified it as a Critical Coastal Area and one of ten high priority watersheds in the state (CCC 2019). It is one of nine creeks identified by the California Department of Fish and Wildlife for coho salmon recovery (CDFG 2004). The ~~Draft~~ Recovery

[1] Name changed in 2013 to California Department of Fish and Wildlife

Plan for Central California Coast Coho Salmon also identifies San Gregorio Creek as a priority watershed for recovery of endangered species, including coho salmon (NMFS 201<u>2</u>~~6~~).

1.2 Limiting Factors Analysis

To improve understanding of current fisheries habitat conditions and the significance of sediment pollution relative to other factors that may be limiting populations of salmonids, a limiting factors analysis was prepared as part of a Watershed Management Plan (WMP) for San Gregorio Creek (Stillwater Sciences et al. 2010). The limiting factors analysis provides a summary of life history, distribution and status of steelhead, and identifies the following factors limiting steelhead population and recovery:

- Limited winter habitat for age 0+ and age 1+ populations resulting from a natural lack of boulders in some reaches, a lack of large woody debris (LWD), and embeddedness of cobble/boulder substrates by fine sediment.
- Low summer instream flows limiting rearing habitat for age 0+ populations and invertebrate production from riffles.
- Reduced complex pool habitat for age 1+ populations resulting from reduced LWD, fine sediment filling of pools and low instream flows.
- The availability of lagoon habitat offsets habitat restrictions found in the watershed, but it is not always reliable due to the lack of freshwater or breaching of the lagoon in some years.

Historical and existing land use practices in the San Gregorio Creek watershed have resulted in degraded fish habitat conditions that include substrate embeddedness and filling of pools by fine sediments, channel incision and disconnection from adjacent floodplains, insufficient LWD, reductions in stream flows due to surface and groundwater withdrawal, and barriers to fish passage (Stillwater Sciences et al. 2010, Brady et al. 2004, CDFG 2004, Pearce et al. 2007, Becker and Reining 2008, NMFS 2016). Each of these stressors can adversely affect steelhead growth and survival. The contribution of these stressors to degraded fish habitat conditions in the San Gregorio Creek watershed and key findings from the limiting factors analysis are summarized next.

<u>1.2.1 Fine Sediment Supply</u>

Much of the fine sediment in San Gregorio Creek derives from natural erosion processes on moderately to highly erodible geologic material (Wentworth et al. 1985, Brabb et al. 2000). Because of this, substrate material is expected to be more embedded by fine sediments than in other streams consisting of less erodible geologic material. Elevated fine sediment deposition in the stream bed can decrease the availability of suitable spawning beds, summer and winter freshwater rearing habitat, and food supply, all of which adversely affect steelhead growth and survival. The addition of more fine-grained sediment from anthropogenic sources exacerbates this problem. These sources include paved and unpaved roads and trails, current and historical grazing and timber harvest practices, agricultural production and rural development (Becker and Reining 2008, Titus et al. 2010, Best 2007, 2012, 2016; Brady et al. 2004, PWA 2003, Florsheim 2015a).

1.2.2 Channel Incision

All major streams in the watershed exhibit some degree of entrenchment resulting from channel incision caused by historical land use activities (Thornburg 1998, Brady et al. 2004, Stillwater Sciences et al. 2010, Florsheim 2015). Historical land use activities include timber harvest, livestock grazing, agricultural croplands, and rural development. These activities contributed to channel incision via higher watershed sediment delivery to the stream network, channel encroachment and simplification of channel geometry. Examples of channel modification include road construction along streams, channel realignment for rural development, LWD removal, and construction of instream structures along the channel bed and banks, such as dams, road crossings and bank protection works.

Channel incision is the primary agent of channel habitat simplification and disconnection of the channel from its floodplain. Historical and ongoing channel incision on San Gregorio Creek and its tributaries has greatly reduced the quantity of gravel bars, riffles, side channels and sloughs, as well as the frequency of inundation of adjacent floodplains. These features and processes are needed to provide essential spawning and juvenile rearing habitat for steelhead. Therefore, channel incision appears to be a key factor limiting steelhead in San Gregorio Creek and its tributaries.

1.2.3 Floodplain Disconnection

When inundated regularly during the wet season, floodplains provide essential habitat for coho salmon, steelhead, and other native fishes (Swales and Levings 1989, Solazzi et al. 2000). Channel incision, or downcutting of a channel into its bed, results in a channel cross-section where a stream becomes hydrologically disconnected from the adjacent floodplain except during very large floods. Much lower frequency of floodplain inundation contributes to a variety of adverse impacts to aquatic and riparian habitat, including diminished extent of riparian vegetation on the valley floor and diminished complexity of channel and floodplain topography (e.g., loss of side channels, sloughs, and other floodplain wetland habitats). The loss of floodplain habitat is thought to be a primary factor in the decline of salmon populations throughout Pacific coastal streams (Beechie et al. 2001, Giannico and Hinch 2003).

Watershed development and management actions have interacted to cause the observed channel incision and habitat simplification on San Gregorio Creek, and to fundamentally alter channel sediment delivery, transport, and storage. Under natural conditions, floodplains along San Gregorio Creek stored a portion of the sediment delivered from upstream reaches. Floodplain disconnection results in more water and sediment being conveyed through the incised (enlarged and deeper) stream channel rather than overtopping the channel banks and flowing out onto the floodplain. As a result, it is likely that the concentration of sand and very fine gravel in the streambed is elevated above the natural background level, the streambed is much more mobile during high flows, and the quality of spawning and rearing habitat is substantially degraded. Compared to historic levels, floodplain disconnection also reduces input rates of LWD to channels and leads to reduced LWD volumes in the stream channel. In channels draining old-growth redwoods, debris jams can store several decades or more of potential bedload supply (Keller et al. 1995). Consequently, San Gregorio Creek and its tributaries have a greatly diminished capacity to sort, store, and meter sediment because of floodplain disconnection and a significant reduction in large woody debris loading.

1.2.4 Instream Substrate

Substrate embeddedness by fine sediment is well documented in San Gregorio Creek and its tributaries (Stillwater Sciences et al. 2010, Brady et al. 2004, Balance Hydrologics 2007, Pearce et al. 2007, Becker and Reining 2008, Titus et al. 2010). The reduced availability of winter rearing habitat due to substrate embeddedness, particularly of cobble-boulder habitat, was found to be a limiting factor for steelhead in San Gregorio Creek (Stillwater Sciences et al. 2010). Cobble-boulder habitat frequently occurs in the tributaries of San Gregorio Creek due to the presence of coarse sediment supplies from active landslide and debris flow areas. When there is significant fine material causing embeddedness, substrate is less favorable for both winter and summer rearing with consequent adverse impacts to survival. Juvenile steelhead use open spaces between clusters of large cobbles and/or boulders as winter refuges from predators and high flows (Hartman 1965; Chapman and Bjorn 1969; Bustard and Narver 1975, Huber et al. 2011, Ligon et al. 2016). This is particularly important for winter rearing because higher flows in winter require juveniles to seek refuge deeper in the substrate than during summer low flows. Density and suitability of these open spaces can be degraded by increases in the supply of sand and gravel delivered to the channel (Cover et al. 2008).

The Watershed Management Plan (Stillwater Sciences et al. 2010) reported abundant suitable spawning habitat in the San Gregorio Creek watershed but with high levels of substrate embeddedness at pool tail outs that could affect spawning and fry survival. Embeddedness of spawning habitat was viewed as secondary to the more acute lack of rearing habitat in the watershed. Successful steelhead reproduction depends on adequate water flow through gravel for eggs to hatch and larvae to grow. If fine sediment clogs the gravel, flow can be very slow and result in high egg mortality rates with few young fish (fry) emerging from the stream bed. In addition, scour of spawning gravel during high stream flows can be a significant source of mortality to incubating eggs and larvae of salmon and trout species (Montgomery et al. 1996, Schuett-Hames et al. 1996). Human actions that increase rate of sediment supply, and/or cause it to become finer will cause the streambed to become finer and more mobile (Dietrich et al. 1989, Buffington and Montgomery 1999a), increasing the depth and/or spatial extent of scour (Carling 1987).

In addition to its adverse effects on spawning and rearing habitat, embeddedness also affects food supply. Elevated fine sediment deposition in the stream bed can cause significant decreases in growth and survival of juvenile salmonids during freshwater rearing by reducing the availability of prey species (Suttle et al., 2004, Harvey et al. 2009). In addition, reduced food availability can result in increasing activity level, aggressive behavior, and attacks between juvenile salmonids (Suttle et al. 2004). Brady et al. (2004) found that the main limitation on fish rearing in lower La Honda Creek was food resources affected by low summertime flows and embeddedness as well as potentially overall water quality.

1.2.5 Instream Habitat Structure

The most important control on steelhead population in San Gregorio Creek is the availability of suitable juvenile rearing habitat for the first year or more (Stillwater Sciences et al. 2010). This habitat is degraded in both the watershed and lagoon and appears as a simplification of channel morphology, hydraulic variability, and floodplain connectivity. Instream habitat structure is adversely affected by reductions in large woody debris (LWD) loading, disconnection of floodplains due to channel incision, increases in fine sediment supply, and low instream flows in summer and fall.

There is a lack of sufficient LWD in most major streams in the San Gregorio Creek watershed (Stillwater Sciences et al. 2010, Alford 2013). An exception is La Honda Creek where Brady et al. (2004) reported that existing LWD volume was relatively high with a high annual rate of recruitment when compared to rates in northern California redwood forests as a whole (Montgomery et al. 1995, Carroll and Robison 2007, Issel 2015). Declines in LWD are due to historical logging; removal of instream LWD, mainly from the 1960s to the 1990s when it was believed to impede fish passage (Florsheim 2015a); floodplain disconnection resulting from historical channel incision (Alford 2013); and, to a limited extent, the selective removal of LWD by public works agencies to reduce flood risk, erosion hazards, and to provide instream structure protection.

Similar to cobble and boulder substrate material, LWD provides valuable winter refuge that acts as hydraulic and physical cover (Lisle 2002, Dolloff and Warren 2003). LWD adds structure, provides refugia, traps sediment, increases channel stability in some cases, creates deep pools and habitat variability, and improves food supply for steelhead (Alford 2013). LWD, particularly large trees, can force pools and bars to form, cause sediment to be sorted into discrete patches (that vary in grain size), and create side channels, islands, and floodplains that are ideal in creating instream habitat structure for steelhead. Studies by Issel (2015) on San Gregorio Creek and Brady et al. (2004) on lower La Honda Creek document the linkage between LWD and deep pool formation. Both studies found that LWD forms pools with greatest depth, cover and complexity and that a lack of LWD resulted in shallower pool depths with low shelter value and little instream cover. Pool spacing was also affected by LWD, with more pools per channel width in streams when high levels of LWD were present versus fewer pools per channel width at low levels of LWD. Similar findings are reported in CDFG stream surveys (Zatkin 2002), which state that a lack of LWD is thought to prevent scour formation and maintenance of deep pools. Due to historical declines in LWD in the San Gregorio Creek watershed, stream surveys have found pools to be abundant but frequently shallow, with most instream cover provided by cobbles and boulders rather than LWD (Zatkin 2002; Baglivio and Kahles 2006a, b, c; Issel 2015). In contrast, Brady et al. (2004) stated that about three-quarters of all the pools on lower La

Honda Creek were associated with or formed by LWD and that adequate refugia and pool availability existed for spawning, all due to adequate LWD volumes. They found that the main limitation was food resources affected by low summertime flows, embeddedness, and potentially overall water quality.

Substantial reduction in wood loading and disconnection of floodplain habitat precludes the elevated sediment supply in San Gregorio Creek from being effectively metered or well sorted within the bed (Keller et al. 1995, Buffington and Montgomery 1999b). Consequently, streambed scour likely is more frequent and extensive following episodic sediment pulses. Pool filling also occurs via elevated fine sediment transport from upstream and has been identified as reducing pool depths and habitat availability in the watershed (Balance Hydrologics 2006, Titus et al. 2010, SFBRWQCB 2018).

1.2.6 San Gregorio Lagoon

Becker et al. (2010) reported that a substantial portion of smolt production occurred in San Gregorio lagoon and that lagoon quality probably had the largest effect on steelhead production in the watershed. The lagoon is seasonal and forms during dry months when wave action creates a sandbar across the creek mouth, effectively blocking freshwater flows from entering the Pacific Ocean. At its peak, the lagoon grows to about 25 acres with about 5 acres in the creek channel upstream of the Highway 1 bridge (Stillwater Sciences et al. 2010). The lagoon provides ideal rearing habitat for steelhead, including cool temperature, high dissolved oxygen and abundant food supplies (Smith 1990).

The sandbar forms a continuous beach along the Pacific Ocean that is naturally breached by high flows from San Gregorio Creek in fall and winter. Artificial breaching is a regular occurrence during summer months and can severely degrade habitat quality for juvenile steelhead in the lagoon (Stillwater Sciences et al. 2010, NMFS 2016). Specific causes of artificial breaching are not reported in the literature, but we assume it is linked to the nearly 400,000 visitors the beach receives each year, mainly during the summer months (Corps 2015). In cases when the sandbar was not breached, Smith (1990) found more than 10,000 rearing juvenile steelhead and Atkinson also reported large numbers in 2005 and 2006 (Atkinson 2010). Most of the rearing area in the lagoon is upstream of highway 1, some of which was eliminated following construction of the highway 1 bridge and connection of the adjacent marsh to the creek via a culvert (Swenson 1997).

1.2.7 Fish Barriers

Numerous artificial barriers to fish passage have been documented in the San Gregorio Creek watershed (Stillwater Sciences et al. 2010). Many of these structures present direct or indirect (e.g., flow-related) barriers and/or impediments to adult steelhead spawning migration into the tributaries and/or the migration of juvenile steelhead out of the tributaries as smolt. These structures include small dams, weirs or other constructed features used for water diversion or impoundments, as well as culverts and bridges at road crossings. Barriers restrict access for steelhead and coho to up to three miles of potential spawning habitat in the watershed (Ross Taylor and Associates 2004, CDFW 2019).

1.2.8 Low Stream Flows

Low instream flows in San Gregorio Creek have been identified as a limiting factor affecting the availability of summer rearing habitat for steelhead populations in San Gregorio Creek (CDFG 1996, Pearce et al. 2007, Alford 2008, Stillwater Sciences et al. 2010, Stillwater Sciences 2014; NMFS 2016). Stillwater Sciences (2014) examined available flow data for San Gregorio Creek and found that flows were usually sufficient for steelhead migration, spawning and fry survival to emergence, but that low flows in summer and fall months limited complex pool habitat for juvenile steelhead.

Land use activities significantly affect base flows in San Gregorio Creek, particularly during the dry season in summer and fall. The Watershed Management Plan (Stillwater Sciences et al. 2010) reported 258 known points of water diversion in the San Gregorio Creek watershed. Surface water (riparian) rights to San Gregorio Creek flows were adjudicated in 1993 by the Superior Court of San Mateo (Superior Court of San Mateo, Decree #355792). The adjudication established a minimum bypass flow requirement of 2 cubic feet per second (cfs) during dry months that applied to all new, post-adjudication water diversions. Existing riparian water users, however, could withdraw water below the 2 cfs limit, and their ability to withdraw water to the maximum extent of their water rights was preserved. A study of available flow data on San Gregorio Creek found that instream flows fell below 2 cfs a little more than half the time from June through November, based on gage data from 1970 to 2009 (Stillwater Sciences 2014). Low flows are a stressor in that they reduce available habitat area, pool depth, and food supply via invertebrate productivity and downstream transport (Harvey et al. 2006).

Following the 1993 restrictions on new riparian (or activation of unexercised riparian rights) water rights in San Gregorio Creek, sources of water supply for land use activities shifted from instream water diversions to ground water pumping. In 2010, there were an estimated 311 groundwater wells in the San Gregorio Creek watershed, located mostly in the eastern half of the basin, with about 20 new wells drilled each year (Stillwater Sciences et al. 2010). No monitoring data for groundwater wells is available and there is no information regarding their effect on the groundwater aquifer; however, the Watershed Management Plan (Stillwater Sciences et al. 2010) presents a preliminary framework for investigating groundwater conditions.

2.0 LIST OF REFERENCES

Alford, C. 2008. Parallel passageways: an assessment of salmon migration in the San Gregorio watershed, Restoration of Rivers and Streams Class Paper (LA 227), UC Berkeley, 24 p.

Alford, C. 2013. San Gregorio Creek Large Woody Debris Inventory and Assessment Report, prepared for San Mateo County Resource Conservation District, American Rivers California Conservation Program, Publication No. AR-CA-2013-01, 44 p.

Anderson, K.R. 1995. A status review of the coho salmon (*Oncorhynchus Kisutch*) in California south of San Francisco Bay, California State Department of Fish and Game, Region 3, Monterey, CA, 98 p.

Atkinson, K. A. 2010. Habitat conditions and steelhead abundance and growth in a California lagoon. Master's Thesis. San Jose State University, San Jose, CA, 118 p.

Baglivio, K., and T. Kahles. 2006a. Stream inventory report: Harrington Creek. Prepared by California Conservation Corps for Midpeninsula Regional Open Space District, Los Altos, California.

Baglivio, K., and T. Kahles. 2006b. Stream inventory report: Bogess Creek. Prepared by California Conservation Corps for Midpeninsula Regional Open Space District, Los Altos, California.

Baglivio, K., and T. Kahles. 2006c. Stream inventory report: La Honda Creek. Prepared by California Conservation Corps for Midpeninsula Regional Open Space District, Los Altos, California.

Balance Hydrologics, Inc. 2006. Initial findings of sediment source survey and creek sedimentation, El Corte de Madera Creek Open Space Preserve, San Mateo County, California, prepared for Midpeninsula Regional Open Space District, Los Altos, CA, 51 p.

Becker, G.S. and I.J. Reining, 2008. Steelhead/Rainbow Trout (*Oncorhynchus mykiss*) resources south of the Golden Gate, California, prepared for the California State Coastal Conservancy and the Resources Legacy Fund Foundation by the Center for Ecosystem Management and Restoration, 425 p.

Best, T.C. 2007. Road and trail erosion inventory: La Honda Open Space Preserve. Prepared for Midpeninsula Regional Open Space District, Los Altos, California.

Best, T.C. 2012. Road and trail erosion inventory: Mindego Ranch Area, Russian Ridge Open Space Preserve. Prepared for Midpeninsula Regional Open Space District, Los Alto, California.

Best, T.C. 2016. 2016 Road and trail erosion inventory and re-assessment: El Corte de Madera Creek Open Space Preserve. Prepared for Midpeninsula Regional Open Space District, Los Altos, California.

Brady, R.H., S. Overton, S. Pearce, L. McKee, and C. Striplen. 2004. Fluvial geomorphology, hydrology, and riparian habitat of La Honda Creek along the Hwy 84 transportation corridor, San Mateo County, California, prepared for California Department of Transportation District 4, Contract No. 04A0400-A01, 317 p.

Brabb, E.E., R.W. Graymer, and D.L. Jones. 2000. Geologic map and map database of the Palo Alto 30' x 60' quadrangle, California, U.S. Geological Survey, Miscellaneous Field Studies Map MF-2332, 2 sheets.

Buffington, J. M., and D. R. Montgomery, 1999a. "Effects of sediment supply on surface textures of gravel-bed rivers." *Water Resources Research* Vol. 35, No. 11: 3523-3530.

Buffington, J. M., and D. R. Montgomery, 1999b. "Effects of hydraulic roughness on surface textures in gravel-bed rivers." *Water Resources Research* Vol. 35, No. 11: 3507-3521.

CCC (California Coastal Commission), 2019. San Gregorio Creek critical coastal area factsheet, CCA #30, 2 p.

CDFG (California Department of Fish and Game), 1996a. Steelhead Restoration and Management Plan for California, Sacramento, California, 234 p.

CDFG (California Department of Fish and Game). 2004. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Sacramento, California, 598 p.

CDFW (California Department of Fish and Wildlife), 2019. Passage Assessment Database (PAD). Web: https://nrm.dfg.ca.gov/PAD/Default.aspx (accessed March 2019)

Carling, P.A., 1987. "Bed stability in gravel streams with reference to stream regulation and ecology." In: *River Channels: Environment and Process* by K.S. Richards. Oxford, U.K.: Blackwell Scientific Publications, Ltd., pp. 321-347.

Carroll, S. and G. Robison. 2007. The effects of large wood on stream channel morphology on three low-gradient stream reaches in the Coastal Redwood Region, USDA Forest Service General Technical Report PSW-GTR-194.

Chapman, D.W., and T.C. Bjorn, 1969. "Distribution of salmonids in streams with special reference to food and feeding." In *Symposium on Salmon and Trout in Streams*. Edited by T.G. Northcote, H.R. MacMillan Lectures in Fisheries, Institute of Fisheries, University of British Columbia, Vancouver, Canada, pp. 153-176.

Commissioners of Fisheries, 1872. Report of the Commissioners of Fisheries of the State of California for the years 1870 and 1871, Sacramento, CA, 24 p.

Corps (U.S. Army Corps of Engineers, San Francisco District), 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing, prepared for the California Coastal Sediment Management Workgroup, 306 p.

Cover, M.R., C.L. May, W.E. Dietrich, and V.H. Resh, 2008. "Quantitative linkages among sediment supply, streambed fine sediment, and benthic macroinvertebrates in northern California streams." Journal North American Benthological Society 27 (1): 135-149.

Dietrich, W.E., J.W. Kirchner, H. Ikeda., and F. Iseya 1989. "Sediment supply and the development of the coarse surface layer in gravel-bedded rivers." *Nature* 340: 215–217.

Dolloff, C.A and M.L. Warren, Jr. 2003. Fish relationships with large wood in small streams, American Fisheries Society Symposium, 37: 179-193.

Florsheim, J. 2015. San Gregorio Creek Rapid Sediment Budget, prepared for the San Francisco Bay Regional Water Quality Control Board, Earth Research Institute, University of California at Santa Barbara, 39 p.

Hartman, G.F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri), Journal of Fisheries Research Board of Canada 22: 1035-1081.

Harvey, B. C., R. J. Nakamoto, and J. L. White. 2006. Reduced streamflow lowers dry-season growth of rainbow trout in a small stream. Transactions of the American Fisheries Society 135:998–1005.

Harvey, B.C., J.L. White, R.J. Nakamoto, 2009. "The Effect of deposited fine sediment on summer survival and growth of rainbow trout in riffles of a small stream." *North American Journal of Fisheries Management* 29: 434-440.

Huber, E., S. Kayed, and C. Post. 2011. Relationship between juvenile steelhead survival and winter habitat availability, LA 222 Class Project, University of California at Riverside, 17 p.

Issel, J.M. 2015. Pool spacing in San Gregorio Creek, California, Master's Thesis, San Francisco State University, 51 p.

Keller, E.A., A. Macdonald, T. Tally, N.J. Merrit, 1995. "Effects of large organic debris on channel morphology and sediment storage in selected tributaries of Redwood Creek, northwestern California." In *Geomorphic processes and aquatic habitat in the Redwood Creek basin, northwestern California.* US Geological Survey Professional Paper 1454-P, 32 p.

Ligon, F.K., R.J. Nakamoto, B.C. Harvey, and P.F. Baker. 2016. Use of streambed substrate as refuge by steelhead or rainbow trout *Oncorhynchus mykiss* during simulated freshets, Journal of Fish Biology, volume 88, pp. 1475-1485.

Montgomerey, D.R., J.M. Buffington, R.D. Smith, K.M. Schmidt, and G. Press. 1995. Pool spacing in forest channels, Water Resources Research, 31(4), pp 1097-1105.

Montgomery, D.R., J.M. Buffington, N.P. Peterson, D. Schuett-Hames, and T.P. Quinn, 1996. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival, Canadian Journal of Fisheries and Aquatic Sciences 53: 1061-1070.

NMFS (National Marine Fisheries Service), 2012. Volumes I - IV, Recovery Plan for the Evolutionary Significant Unit of Central California Coast Coho Salmon, National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service), 2016. Final Coastal Multispecies Plan, Volume IV, Central California Coast Steelhead, National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

PWA (Pacific Watershed Associates), 2003. Sediment assessment of roads and trails within the Pescadero/Memorial/Sam McDonald County Park Complex, Pescadero Creek Watershed, San Mateo County, California, prepared for San Mateo County Parks and Recreation Department and California Department of Fish and Game, Contract #39000-02-C212.

Pearce, S., Gilbreath, A., and McKee, L., 2007. Stream Inventory Report for La Honda Creek. A technical report of the Watershed Program, San Francisco Estuary Institute (SFEI), Oakland, California. SFEI contribution no. 529.

Ross Taylor and Associates. 2004. Catalog of San Mateo County stream crossings with culverts located on anadromous stream reaches. Prepared for County of San Mateo, Department of Public Works, San Mateo, California.

SFBRWQCB (San Francisco Bay Regional Water Quality Control Board). 2018a. Total maximum daily load for sediment and habitat enhancement plan for Pescadero-Butano Watershed, Final Staff Report, 231 p.

Schuett-Hames, D., B. Conrad, A. Pleus, and K. Lautz. 1996. Literature review and monitoring recommendations for salmonid spawning gravel scour, Northwest Indian Fisheries Commission and Washington Department of Fish and Wildlife, TFW Ambient Monitoring Program, TFW-AM-9-96-001, 26 p.

Skinner, J.E. 1962. An historical review of the fish and wildlife resources of the San Francisco Bay area, Water Projects Branch Report No. 1, State of California Department of Fish and Game, Sacramento, CA, 226 p.

Smith, J. J. 1990. The effects of sandbar formation and inflows on aquatic habitat and fish utilization in Pescadero, San Gregorio, Waddell and Pomponio Creek Estuary/Lagoon systems, 1985-1989. Prepared by Department of Biological Sciences, San Jose State University, California, 103 p.

Stillwater Sciences, Stockholm Environment Institute, and San Gregorio Environmental Resource Center, 2010. San Gregorio Creek Watershed Management Plan, prepared for Natural Heritage Institute, 151 p.

Stillwater Sciences, 2014. Ecological assessment of flows in San Gregorio Creek. Appendix to: San Gregorio Creek watershed management plan. Final Report. Prepared for American Rivers, Nevada City, California.

Suttle, K.B., Power, M.E., Levine, J.M., and C. McNeely 2004. "How fine sediment in riverbeds impairs growth and survival of juvenile salmonids." *Ecological Applications* 14(4): 969-974.

Swenson, R. O. 1997. The ecology, behavior, and conservation of the tidewater goby, Eucyclogobius newberryi. Environmental Biology of Fishes 55: 99-114.

Titus, R.G, Erman, D.C. and W.M. Snider. 2010. 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, 286 p.

Wentworth, C.M., S. Ellen, V.A. Frizzell, Jr, J. Schlocker, 1985. Map of hillside materials and description of their engineering character, San Mateo County, California, U.S. Geological Survey Miscellaneous Investigations Series, Map I-1257-D, 2 sheets.