

California Regional Water Quality Control Board
San Francisco Bay Region

Lagunitas Creek Nutrient Impairment Analysis



Final Staff Report
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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

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1 Summary

This report evaluates nutrient impairment and biological condition in the mainstem of Lagunitas Creek. A similar report for an analogous study in Walker Creek will be made available after data collection ends in 2024. For the Lagunitas Creek study, samples were collected and analyzed for a suite of water chemistry analytes (ammonia, nitrate, nitrite, total nitrogen, orthophosphate, and total phosphorous) and algae biomass indicators (benthic and water column chlorophyll-a). Additionally, California Stream Condition Index (CSCI) scores were used to assess overall stream health. Since there are no numeric Water Quality Objectives or U.S. EPA criteria for algae-based indicators to determine if a water's beneficial uses are impaired by eutrophication, a reference site and weight of evidence approach was used to assess impairment. Nutrient concentrations were not elevated relative to reference sites in the San Francisco Bay Region. Based on the current reference evaluation guidelines, there is sufficient information to demonstrate Lagunitas Creek is fully supporting beneficial uses according to the Water Quality Control Policy for developing California's Clean Water Act Section 303(d) List (the [Listing Policy](#)). The Surface Water Ambient Monitoring Program (SWAMP) is currently studying nutrient concentrations at pristine reference sites throughout the San Francisco Bay Region. Results from that study will be used to refine nutrient evaluation guidelines; if evaluation guidelines change as a result of that study, this analysis will be updated to include the new evaluation guidelines.

2 Lagunitas Creek Nutrient Impairment Analysis

2.1 Lagunitas Creek Watershed

The Lagunitas Creek watershed encompasses 103 square miles in Marin County and drains into Tomales Bay. It is protected habitat for coho salmon, steelhead trout, and California freshwater shrimp. Current and historic land use in the watershed includes grazing, logging, row crops, golf courses, and residential communities on septic. A large portion of the watershed is open space which offers hiking and equestrian trails. Major tributaries include Halleck Creek, Nicasio Creek, Olema Creek, and San Geronimo Creek. Lagunitas Creek was listed as impaired for indicator bacteria (pathogens) in 1992 and nutrients in 1996 on the Clean Water Act 303(d) List. A [total maximum daily load](#) (TMDL) to control sources of bacteria was approved by U.S. EPA in 2007. Since it is listed as nutrient impaired, a nutrient TMDL is also required but has not been developed. Lagunitas Creek is included in the [Tomales Bay Grazing Waiver Program](#), which was developed to control nonpoint sources of bacteria, sediment, and mercury entering Tomales Bay. It is also included in the [Confined Animal Facility Program](#), which controls bacteria from manure waste collection and disposal. These programs have the added benefit of reducing nutrients entering the creek from animal operations.

2.2 Eutrophication and Nutrient Impairment

Elevated nutrients (nitrogen and phosphorus) in surface waters can lead to nuisance algae growth, also known as eutrophication. Nuisance algae can impair recreational beneficial uses by creating unsightly conditions and may increase the occurrence of [algal toxins](#). Nuisance algae also blocks sunlight and when it decomposes, it can deplete the water's supply of dissolved oxygen, which is essential for aquatic life. Changes in nutrient loading, light conditions, temperature, flow, and physical habitat are all factors that influence algal growth (Sutula et al., 2018). Thus, if conditions are not suitable, nuisance algal growth may not be observed even if nutrients are elevated.

Currently, there are no numeric Water Quality Objectives or U.S. EPA criteria for algae-based indicators to determine if a water's beneficial uses are impaired by eutrophication. There are

different approaches to evaluating nutrients and eutrophication in streams and rivers. Nutrient and biological conditions at reference sites (i.e., sites that are unimpacted or minimally impacted by humans), can provide useful thresholds for comparison when numeric Water Quality Objectives are not available, as discussed in the U.S. EPA Nutrient Criteria Technical Guidance Manual (2000). Reference status for nutrient and bioassessment sampling sites were determined according to the method described by [Ode et al. \(2015\)](#). Briefly, reference status was determined by land use and land-cover metrics that quantify natural characteristics and anthropogenic stressors at or upstream of sampling sites. For this study, sites excluded by the reference tool were added back to the reference pool if best professional judgement showed the tool misidentified a source of impact (e.g., flagged for agriculture when there is no agriculture in the watershed); the impacts were believed to be minimal (e.g., minimally used roads in a protected area); or it was part of a long-term reference study that was established before the reference screening tool was developed. Less than fifteen percent of reference sites (18 of 131 sites) were added back to the reference pool using best professional judgement. In addition to the reference site approach, a weight of evidence approach, or evaluating data for multiple endpoints (e.g., biological communities, habitat, water chemistry), can help determine if beneficial uses are supported. The assessment thresholds used for this weight of evidence approach are described in Section 2.4.

2.3 Lagunitas Creek Nutrient Study

In summer 2016 and 2017, San Francisco Regional Water Board staff conducted a study to evaluate the nutrient impairment in the Lagunitas Creek watershed. A similar study was conducted in the Walker Creek watershed; results from that study will be summarized in a nutrient impairment analysis report after data collection ends in 2024. For the Lagunitas Creek study, data were collected following Surface Water Ambient Monitoring Program (SWAMP) standard operating procedures (SOPs) for [water samples](#) and [bioassessment](#) and analyzed according to SWAMP's [measurement quality objectives](#). Data collected by SWAMP satisfies the data quality requirements of section 6.1.4 of the Policy. Laboratory results and field observations are made available through the [California Environmental Data Exchange Network](#) (CEDEN).

Samples were collected and analyzed for a suite of water chemistry analytes (ammonia, nitrate, nitrite, total nitrogen, orthophosphate, and total phosphorous) and algae biomass indicators (benthic and water column chlorophyll-a) according to the [SWAMP Bioassessment SOP](#). Per the same protocol, in-stream and riparian physical habitat and stream temperature data were also collected to evaluate the potential for eutrophic conditions. An additional study from 2019-2022 was conducted to evaluate the extent of nutrient and bacteria impairment in San Geronimo Creek; as part of this study, nutrient samples were collected from Lagunitas Creek directly above and below the confluence with San Geronimo Creek.

This report evaluates nutrient impairment and biological condition in the mainstem of Lagunitas Creek. The dataset used to evaluate nutrient impairment in the Lagunitas Creek mainstem fulfills the Listing Policy's requirement for spatial and temporal representativeness. Nutrient chemistry data were collected from 2001-2002, 2016-2017, and 2019-2022 and benthic algae-based data were collected in 2016 and 2017. Nutrient conditions in tributaries were not considered in this report because this study was designed to have sufficient spatial and temporal representation of the main stem and that sampling effort would be too large of a study if conducted on separate tributaries. In addition, the [Onsite Wastewater Treatment Systems](#) (OWTS) policy Tier 3 status applied to the Lagunitas Creek mainstem prior to the study and a focus of this study was to determine impairment status to justify removal of this waterbody from the OWTS Tier 3 in 2023. A nutrient and bacteria impairment assessment for San Geronimo Creek will be summarized in a separate report.

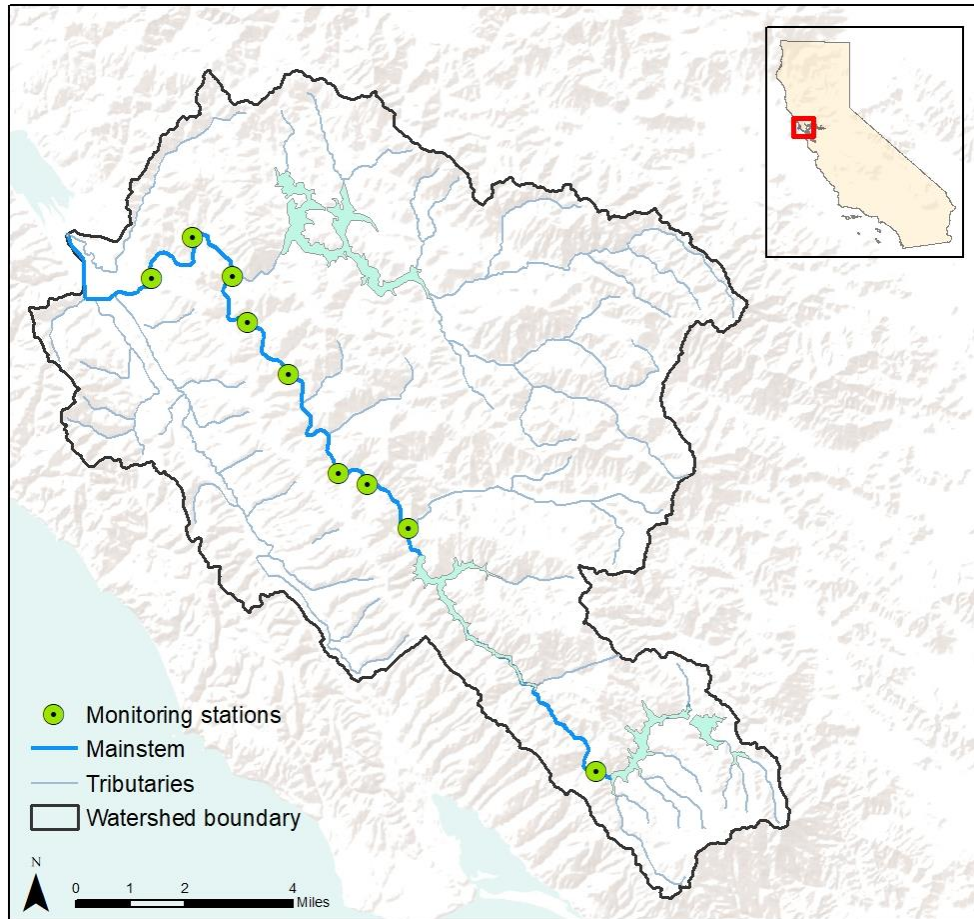


Figure 1. Map of the Lagunitas Creek watershed including SWAMP sampling sites on the Lagunitas Creek mainstem.

2.4 Analysis Approach and Assessment Thresholds

Nutrient concentrations and biological indicators were compared to numeric evaluation guidelines. Assessment thresholds and exceedances for this analysis are summarized in Table 1. According to the Listing Policy, a waterbody is considered impaired if the water quality objective is exceeded seventeen percent of the time. Nutrients in Lagunitas Creek are being considered for removal from the Clean Water Act section 303(d) List under section 4.11 of the Listing Policy. Under this section, when all other delisting factors do not result in the delisting of a water segment but information indicates attainment of standards, a water segment shall be evaluated to determine whether the weight of evidence demonstrates that the water quality standard is attained. If the weight of evidence indicates attainment, the water segment shall be removed from the Clean Water Act section 303(d) List. The evaluation of nutrients requires the weight of evidence approach because the nutrient concentrations alone are not enough to cause eutrophication in streams; if conditions are not suitable, nuisance algal growth may not be observed even if nutrients are elevated. For the lines of evidence regarding nutrients with direct toxic effects (e.g., un-ionized ammonia, total ammonia, nitrate, and nitrite), Listing Policy Table 4.1 criteria for toxicants was used to show that exceedances have been below the maximum number of exceedances allowed to remove a water segment and that municipal and aquatic life beneficial uses were not affected by nutrient toxicity.

Table 1 – Assessment Thresholds and Exceedances

Analyte	Numeric Evaluation Guideline	Evaluation Guideline Source	Number and Percent of Exceedances
Ammonia	0.6-3.3 mg/L	2013 U.S. EPA Aquatic Life Ambient Water Quality Criteria for Ammonia in Freshwater	0/32 (0%)
Nitrate as N (MUN)	10 mg/L	Basin Plan	0/32 (0%)
Nitrite as N (MUN)	1 mg/L	Basin Plan	0/32 (0%)
Nitrate as N	0.2462 mg/L	90 th percentile of R2 reference streams	2/32 (6%)
Total Nitrogen as N	0.736 mg/L	90 th percentile of R2 reference streams	0/32 (0%)
Phosphorus as P	0.107 mg/L	90 th percentile of R2 reference streams	0/32 (0%)
Orthophosphate	0.1157	90 th percentile of R2 reference streams	0/32 (0%)
Percent Presence Macroalgae	30%	New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Stream	1/7 (14%)
Benthic Chlorophyll-a (Beneficial Use Risk Classification I/II boundary)	100 mg/m ²	Technical Approach to Develop Nutrient Numeric Endpoints for California	0/7 (0%)
Water Column Chlorophyll-a	15 µg/L	Interpreting Narrative Objectives for Biostimulatory Substances for California Central Coast Waters	0/7 (0%)
California Stream Condition Index (CSCI)	0.79	CSCI Technical Memo	1/10 (10%)

2.4.1 Nutrient Assessment Thresholds

Nitrogen is an important biostimulatory indicator which can occur in multiple forms in the environment (i.e., organic nitrogen, ammonia, nitrate, and nitrite). Total nitrogen (TN) can be

measured directly in the lab or calculated by summing the different forms of nitrogen. For this analysis, U.S. EPA's nutrient aggregation logic was followed: if TN (as N) was measured and reported by the lab, that measurement was used to represent total nitrogen. If a direct laboratory measure of total nitrogen was not reported, it was calculated as the sum of total Kjeldahl nitrogen (organic nitrogen and ammonia), nitrate, and nitrite.

For this analysis, thresholds for total nitrogen, nitrate, total phosphorus, and orthophosphate were set as the 90th percentile of San Francisco Bay Region reference streams, meaning ninety percent of reference sites will have concentrations at or below that threshold. The existing San Francisco Bay Region reference dataset includes nutrient and bioassessment data from the past 20+ years. In 2023, SWAMP began a special study to monitor nutrient concentrations at reference streams throughout the San Francisco Bay Region. Nutrient evaluation guidelines may be refined in the future after new data are added to the existing reference dataset.

Nitrate and nitrite concentrations were also compared to objectives for municipal supply outlined in the Basin Plan because municipal supply is a designated beneficial use in Lagunitas Creek. Ammonia toxicity was calculated using the [2013 U.S. EPA Aquatic Life Ambient Water Quality Criteria for Ammonia in Freshwater](#).

2.4.2 Algae Biomass Assessment Thresholds

Benthic chlorophyll-a was used to directly quantify the amount of algae in the stream in order to determine if the narrative water quality objective for biostimulatory substances (i.e., eutrophication) was exceeded. Benthic chlorophyll-a was assessed using the Beneficial Use Risk Classification I/II (BURC I/II) boundary, which represents a threshold below which nutrients do not present a significant risk of impairment as described in the [Technical Approach to Develop Nutrient Numeric Endpoints for California](#).

Water column chlorophyll-a was assessed using a 15 µg/L screening level. The Central Coast Regional Water Quality Control Board uses 15 µg/L as a numeric target in the [San Simeon Creek TMDL](#). The basis for this numeric target came from the peer-reviewed study [Interpreting Narrative Objectives for Biostimulatory Substances for California Central Coast Waters](#) by the Central Coast Ambient Monitoring Program (CCAMP; Worcester et al., 2010). Worcester et al. (2010) reported that inland streams in the California central coast region that do not show signs of eutrophication all remained below the 15 µg/L chlorophyll-a threshold. Additionally, the states of [North Carolina](#) and [Oregon](#) both use 15 µg/L for a chlorophyll-a criterion.

Percent presence macroalgae cover was assessed against a 30 percent evaluation guideline. The [New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Stream](#) (Biggs 2000) recommends a maximum of 30 percent cover of filamentous algae in a stream reach to protect aesthetic and contact recreation beneficial uses. This evaluation guideline was used in 2014 to support de-listing Napa River and Sonoma Creek for nutrients.

2.4.3 Biological Stream Health Assessment Threshold

Biological health was assessed using the California Stream Condition Index (CSCI), which translates complex data about invertebrates living in streams into an overall measure of stream health (Rehn et al., 2015). The threshold of 0.79 was used as an evaluation guideline for beneficial use attainment and was selected in conformance with Sections 3.9 and 6.1.5.8 of the Listing Policy. Section 3.9 allows the use of reference site or sites to compare degradation in biological populations and/or communities. Section 6.1.5.8 requires a method of selecting reference sites and applying them to develop an Index of Biological Integrity, which has been done and validated by

the CSCI threshold study authored by Mazor et al. (2016). Sites scoring below 0.79 are considered to have impacted biological communities.

2.5 Results

Zero of thirty-two TN samples exceeded the 0.736 mg/L assessment threshold. Only two of thirty-two nitrate concentrations exceeded the 90th percentile threshold of 0.246 mg/L, which is below the number of exceedances allowed by the Listing Policy. Nitrate concentrations were well below the water quality objective for municipal supply outlined in Table 3-5 of the Basin Plan. Nitrite results were always non-detect, meaning the nitrite concentrations in the samples were too low to be detected by the laboratory analysis. Measured ammonia concentrations never exceeded the [2013 U.S. EPA Aquatic Life Ambient Water Quality Criteria for Ammonia in Freshwater](#). Zero of thirty-two samples exceeded assessment thresholds for total phosphorus and orthophosphate. These data show nutrient exceedances have been below the maximum number of exceedances allowed to remove a water segment according to Table 4.1 of the Listing Policy and municipal aquatic life beneficial uses were not affected by nutrient toxicity.

One of seven sites exceeded the percent presence of macroalgae, but it did not correspond to elevated nutrient concentrations or low biological scores. Zero of seven samples exceeded thresholds for benthic chlorophyll-a and water column chlorophyll-a. Both metrics showed zero exceedances, but there are not enough samples to use the binomial approach in Tables 4.1 or 4.2 of the Listing Policy. However, these measures are fairly consistent over time, so they take into account water quality conditions for weeks to months around the sample date.

According to the Listing Policy, bioassessment metrics such as CSCI scores can't be used by themselves to support listing or delisting a waterbody. However, they can be used as a weight of evidence to support the listing decision. CSCI scores in Lagunitas Creek suggest biological communities are not impacted by human stressors or nutrient toxicity. Three samples scored in the "likely intact" range and three samples scored in the "possibly altered" range. Only one of ten CSCI scores from 2001-2019 in Lagunitas Creek was below the 0.79 threshold. This site was located on Lagunitas Creek 400 meters downstream of Alpine Lake Dam (201LAG385), which is between two reservoirs. The low biological score is likely because biological communities are heavily impacted by the reservoirs.

2.6 Conclusions

There is sufficient information to demonstrate nutrient concentrations in Lagunitas Creek are fully supporting beneficial uses according to the Listing Policy. The weight of evidence indicates Lagunitas Creek is not impaired for eutrophication: nutrients are not elevated compared to reference conditions and algae biomass and stream biological health indicators do not exceed evaluation guidelines. This analysis relied on a weight of evidence approach following Listing Policy 4.11. The data supported removing Lagunitas Creek from Table 6 of the OWTS policy which occurred in 2023. SWAMP recently began a multi-year project to study nutrient concentrations at reference sites in the San Francisco Bay Region. As part of that study, reference-based evaluation guidelines will be updated and refined, as appropriate. If nutrient evaluation guidelines change as a result of the ongoing SWAMP reference site study, this analysis will be updated to include the new evaluation guidelines. As previously mentioned, results from a similar study in Walker Creek will be summarized in a separate report.

3 References

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