



MORRO BAY

NATIONAL ESTUARY PROGRAM



Sediment Monitoring Report

Water Year 2022

Morro Bay National Estuary Program
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PLEASE NOTE: In 2015, we updated the stage-discharge relationship equations for Chorro Creek at Canet Road to better estimate discharges for stage heights less than 12.1 feet. The updated equations created a discontinuity when the rating curve reached 12.1 feet. In September 2024 we released a technical memo describing the discontinuity and providing updated equations, which is available in our library at <https://library.mbnep.org/>. Please be aware that discharge calculations used in this report are considered out of date and must be updated with the equations contained in the technical memorandum.

September 2023

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List of Acronyms

ACOE	Army Corps of Engineers
BMI	Benthic macroinvertebrate
BMP	Best management practices
Cal Poly	California Polytechnic State University, San Luis Obispo
CFS	Cubic feet per second (ft ³ /s)
CSLRCD	Coastal San Luis Resource Conservation District
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera
D50	Median gravel size diameter
ITRC	Irrigation Training and Research Center
MLLW	Mean lower low water
NMP	National Monitoring Program
NTU	Nephelometric turbidity unit
SET	Surface elevation table
SNARL	Sierra Nevada Aquatic Research Laboratory
SSC	Suspended sediment concentration
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Total maximum daily load
TSS	Total suspended solids
USF	University of San Francisco
USGS	United States Geological Survey
WY	Water year

1. Overview

The Morro Bay estuary is impaired by accelerated sedimentation rates. The Morro Bay National Estuary Program (Estuary Program) compiles data annually to assess sedimentation in the watershed and the bay. To that end, the following data are detailed in this report.

- Sediment transport indicators: Ambient water quality data, surface elevation table data, precipitation data, and discharge were compiled to assess the potential for sediment transport on an annual basis.
- Streambed sediment impairment indicators: Watershed-wide bioassessment data was assessed to determine the impacts of sedimentation on aquatic health. Of the six sites assessed by this method, five frequently have scores indicating some level of impairment.

2. Introduction

In 1998, the Central Coast Regional Water Quality Control Board (Water Board) identified Chorro Creek, Los Osos Creek, and the Morro Bay estuary as impaired by sediment and listed the water bodies under Clean Water Act Section 303(d). The Total Maximum Daily Load (TMDL) identified accelerated sedimentation due to anthropogenic disturbance as the primary cause for the listing. TMDL documentation cited the 1998 Tetra Tech report estimates that the subwatersheds of Chorro and Los Osos Creeks deliver an average of approximately 70,000 tons per year of sediment into the Morro Bay estuary. The report indicated that the Chorro Creek watershed was estimated to contribute 86% of the total sediment delivered to Morro Bay, approximately 60,689 tons.

The *Morro Bay Total Maximum Daily Load for Sediment* was formally adopted by the Environmental Protection Agency (EPA) on December 3, 2003. The TMDL calls for a 50% reduction in the annual loading to Morro Bay. Sediment loads less than 34,885 tons per year would comply with the TMDL targets. This TMDL would be achieved by an average reduction of 607 tons per year over a 50-year time schedule, for compliance by 2052.

The TMDL identified five targets for monitoring and plans to track the progress of voluntary and required implementation actions (Table 1). The Estuary Program was identified as a key monitoring and reporting partner. This report details progress on monitoring to assess sediment conditions in the Morro Bay watershed and estuary during the 2022 water year (WY), which is defined as October 1, 2021 to September 30, 2022.

Four numeric targets were established for the streams in the Morro Bay watershed: pool volume, median gravel size diameter (D50), percent fines in substrate, and percent of coarse fines in substrate. The TMDL identified tidal prism volume as the primary numeric target for Morro Bay. Tidal prism volume assessments are not conducted frequently due to the high cost and because of the time needed between surveys to obtain meaningful results. The most recent survey was conducted in 2019, and analysis of tidal prism calculations are still underway. Results are expected in 2024.

Table 1: Morro Bay Sediment TMDL numeric targets for Chorro and Los Osos creeks and tributaries.

Parameter	Numeric Target
Residual Pool Volume	$v^* = (a \text{ ratio})$
	Mean values ≤ 0.21 (mean of at least 6 pools per sampling reach)
	Max values ≤ 0.45
Median Diameter (D50) of sediment Particles in Spawning Gravels	D50 =
	Mean values ≥ 69 mm
	Minimum values ≥ 37 mm
Percent of Fine Fines (< 0.85 mm) in Spawning Gravels	Percent fine fines $\leq 21\%$
Percent of Coarse Fines (all fines < 6.0 mm) in Spawning Gravels	Percent coarse fine $\leq 30\%$
Morro Bay Estuary	
Tidal Prism Volume	4,200 acre-ft

2.1. Morro Bay Watershed

The Morro Bay watershed is located in San Luis Obispo County on California’s central coast and encompasses a drainage area of approximately 75 square miles. The inland watershed drains west to the Morro Bay estuary and Pacific Ocean via two primary creeks, Chorro Creek and Los Osos Creek.

The Chorro Creek subwatershed encompasses a drainage area of 43.4 square miles. Land use in the subwatershed is primarily agricultural, with much of the area used as rangeland for beef cattle operations. Notable urban areas include the City of Morro Bay, Cuesta College, the California Men’s Colony prison complex, and Army National Guard Base Camp San Luis Obispo (Camp SLO). Chorro Creek receives drainage from several tributaries: Dairy Creek, Pennington Creek, Walters Creek, San Luisito Creek, and San Bernardo Creek.

The Los Osos Creek subwatershed encompasses a drainage area of 23.1 square miles. Land use in the subwatershed is primarily agricultural and residential. In contrast to the Chorro Creek subwatershed, agriculture in the Los Osos subwatershed is characterized by plowed rotational fields generating a variety of forage and truck crops. Much of the intensive farming operations in the watershed occur in the Warden Creek drainage area.

2.2. Morro Bay Estuary

The Morro Bay estuary is comprised of approximately 2,300 acres of shallow, semi-enclosed intertidal and sub-tidal habitat. The estuary is bordered to the west by a four-mile vegetated natural sandspit that separates Morro Bay from the Pacific Ocean (Figure 1).

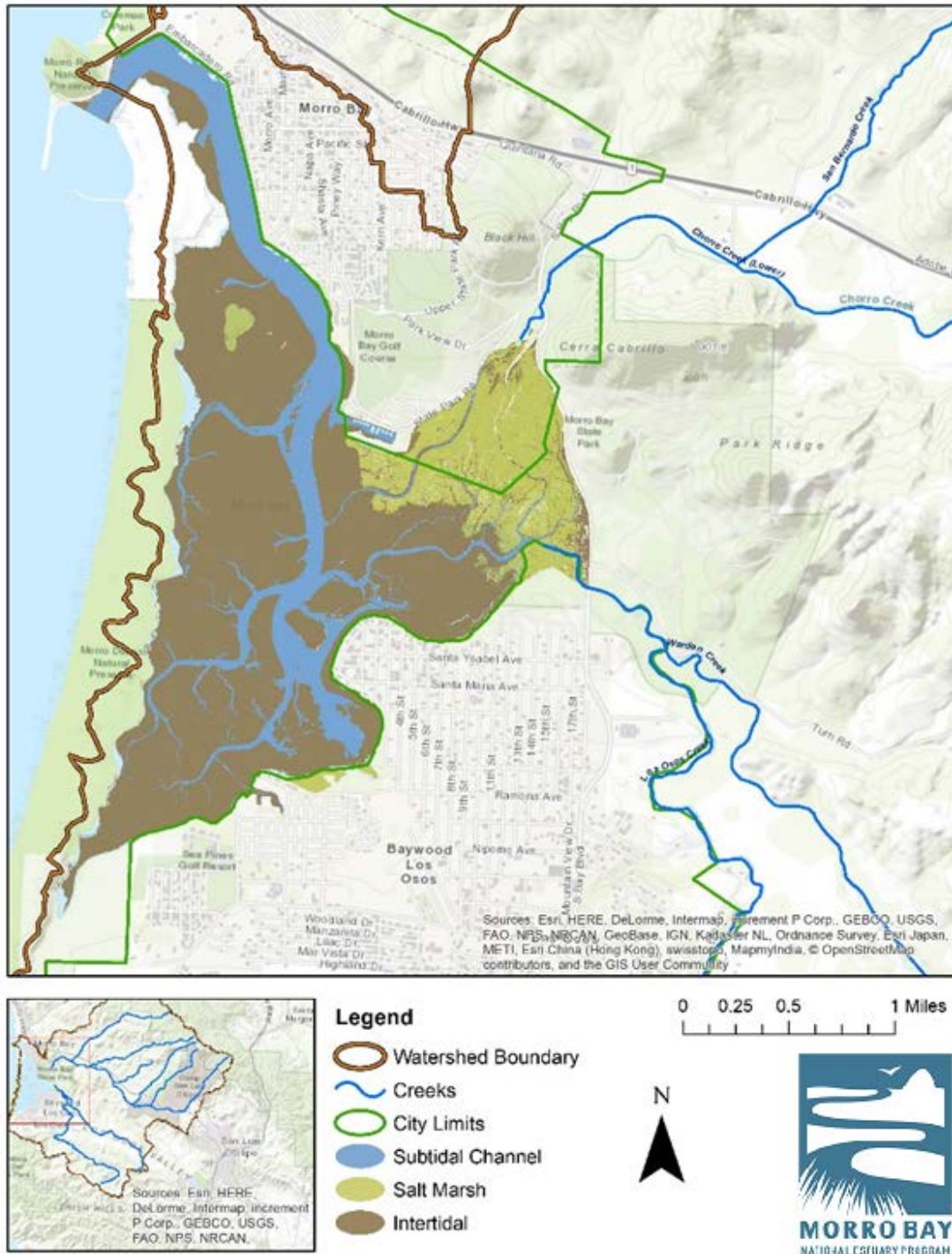


Figure 1: Map of Morro Bay estuary habitat types

Habitats and beneficial uses within the estuary are protected through numerous regulatory frameworks. Morro Bay was established as California's first State Estuary in 1994 and was accepted into the National Estuary Program in 1995. Today, Morro Bay is one of the Environmental Protection Agency's 28 recognized National Estuaries. In 2007, the Morro Bay estuary was incorporated into the California Department of Fish and Wildlife's Marine Protected Areas. Through the Marine Protected Area designations, the intertidal and subtidal habitats within Morro Bay are protected as either a State Marine Recreational Management Area or a State Marine Reserve. All of these frameworks serve to protect important habitat for marine and migratory species.

Zostera marina (eelgrass) is an important component of coastal habitat and provides diverse benefits to coastal marine and migratory species as well as substantial ecosystem services. Eelgrass meadows are known to be highly sensitive to poor water clarity. The Morro Bay estuary once supported the third largest remaining eelgrass beds in Southern California (Bernstein, et. al. 2011). Historic monitoring of eelgrass extent indicated that intertidal eelgrass beds may have spanned up to 500 acres in Morro Bay during the 1970s. In 2010, the Estuary Program estimated that eelgrass covered 176 acres. A survey from December 2017 estimated that just over 13 acres of eelgrass remained in Morro Bay (MBNEP, 2019). A more recent eelgrass survey from fall 2021 indicated approximately 500 acres of eelgrass bay-wide (MBNEP, 2022). This improvement is likely the result of multiple factors, including changing water quality conditions, shifting bay elevations, and eelgrass restoration efforts.

In addition to providing critical marine habitat, Morro Bay is also a popular destination for outdoor recreation, supporting kayaking, sailing, fishing, wildlife observing, and waterfowl hunting. Many of these uses are protected as designated "Beneficial Uses" within the Central Coast Regional Basin Plan administered by the Water Board.

Morro Bay is also an important center for commercial fishing and aquaculture operations. The bay is designated as a Harbor of Safe Refuge and is the only safe harbor between Santa Barbara and Monterey. Maintenance of the harbor as a port for fishing and recreational vessels requires frequent dredging of the main channel. The harbor entrance is dredged annually by the Army Corps of Engineers (ACOE) to maintain a channel depth of approximately 40 feet mean lower low water (MLLW). More information on annual dredging can be found in the [Estuary Program's annual Eelgrass Reports](#).

2.3. Sediment Retention and Erosion Prevention Projects

Numerous projects have occurred in the Morro Bay watershed to prevent sediment erosion and maximize sediment capture and retention within the watershed. The Estuary Program has worked with many local partners to implement projects to help meet TMDL goals. Examples of sediment retention projects in the watershed include:

- **The Chorro Flats Enhancement Project:** The Coastal San Luis Resource Conservation District (CSLRCD) implemented a floodplain restoration project to capture sediment from the Chorro Creek watershed in 1997. The project was designed to capture approximately 610,000 cubic yards of sediment over a 61-year timeframe. An unusual reoccurrence of high magnitude storm flows during the 1990s resulted in large sediment loads reaching the site. By 2001, it was estimated that only 412,000 cubic yards of potential storage area remained (CSLRCD, 2002). Since 2001 there has been limited work to quantify storage capacity or sediment trapping

efficiency at the site. Planning is underway to determine future actions that might be taken at the site to enhance sediment capture and reduce flooding potential.

- **Project Clearwater:** The CSLRCD implemented a broad array of agricultural best management practices (BMPs) throughout the Morro Bay watershed from 2001 to 2008. Work completed as part of “Project Clearwater” included several projects that targeted erosion and sediment loading on private property. Efforts included road drainage improvements, stream bank stabilization, and stream crossing improvements. The BMPs implemented as part of Project Clearwater are estimated to have reduced sedimentation by approximately 9,041 tons (CSLRCD, 2010).
- **Morro Bay Riparian Fencing:** The Estuary Program has worked with public and private landowners to install thousands of feet of riparian fencing within the rangeland area of the Chorro Creek watershed. The installation of fences in riparian areas can yield up to a 66% reduction in sediment load from stream banks and riparian areas (CCRWQCB, 2003). Fencing installations have protected important stream corridors including Dairy Creek, Walters Creek, Pennington Creek, and San Luisito Creek.
- **Walters Creek Restoration:** In addition to riparian fencing work, a suite of restoration efforts and BMPs have been installed throughout the Walters Creek watershed. The Walters watershed served as the ‘control’ site in the National Monitoring Program (NMP) paired watershed study during the 1990s. Following the completion of the NMP in 2001, substantial in-stream restoration work was undertaken on Walters Creek. Cal Poly also implemented grazing regimes and ranch road management practices to help reduce sedimentation.
- **Morro Bay Watershed Road Erosion Prevention Project:** The Estuary Program conducted the Morro Bay Watershed Road Erosion Prevention project from October 2014 through April 2016. This project treated approximately 11 miles of roads within California Polytechnic State University (Cal Poly), Camp SLO, and U.S. Forest Service properties. Over 50 sites were treated with culverts, sediment settling basins, rolling dips, and other measures to reduce sediment delivery to nearby stream systems. Project engineers estimate that this project will eliminate 1,225 tons per year of sediment erosion over ten years.
- **Chorro Creek Ecological Reserve:** In 2019, the Chorro Creek Ecological Reserve restoration project was completed at the site at the base of Hollister Peak. This project was designed to utilize the historical floodplain to allow high-energy creek flows to spread out and drop sediment in areas outside of the main channel, thereby lowering the total load to the estuary and reducing the amount of fine sediments that could degrade habitat quality for sensitive species. As part of this project, approximately 24,000 cubic yards of sediment were removed, a large portion of which would have been flushed down Chorro Creek into the estuary over time.
- **Los Osos Wetland Restoration Project:** The CSLRCD completed an 80-acre wetland restoration project at the confluence of Los Osos Creek and Warden Creek in October 2021. The project focused on reconnecting Warden Creek to its historic floodplain by breaching a 400-foot levee, removing three perched culverts, and decommissioning several upland access roads. By

capturing sediment before it reaches the bay, the restored wetland area will play a critical role in sediment retention within the Los Osos Creek subwatershed.

3. Sediment Transport Indicators

Since the adoption of the sediment TMDL in 2003, numerous monitoring efforts have been undertaken to quantify sediment transport and delivery to Morro Bay. In order to better understand sediment depositional trends in the watershed, the Estuary Program compiles annual data related to sediment transport through ambient water quality site visits, surface elevation table monitoring in Morro Bay, and by analyzing annual precipitation and discharge data.

3.1. Historic Sediment Monitoring

From 2007 to 2019, the Estuary Program monitored suspended sediment concentration (SSC) during storm events using stream gauges and automated samplers. This monitoring spanned over a decade, with the exception of very low-flow or drought years. The SSC data was analyzed by a statistician to create a predictive relationship between sediment concentration and discharge. While this work provided key understanding to sediment transport in the watershed, SSC monitoring was put on hold indefinitely after 2019 due to the labor associated with storm-driven sampling and processing SSC samples.

3.2. Ambient Water Quality

The Estuary Program's Monitoring Program has been conducting routine water quality monitoring throughout the estuary and watershed since 2002. Data is collected on a monthly basis by staff and trained volunteers in compliance with the program's rigorous Quality Assurance Project Plan. Due to safety issues and monitoring constraints, data is collected only during base flow conditions when streams are wadeable. Volunteers and staff measure a variety of water quality parameters including nephelometric turbidity and instantaneous flow volume. While this data is important for understanding long-term ambient trends across the watershed, it does not capture data during major winter storm events.

Figure 3 illustrates a subset of ambient water quality monitoring sites located throughout the watershed. The sites shown are either perennial or semi-perennial and have long running datasets.

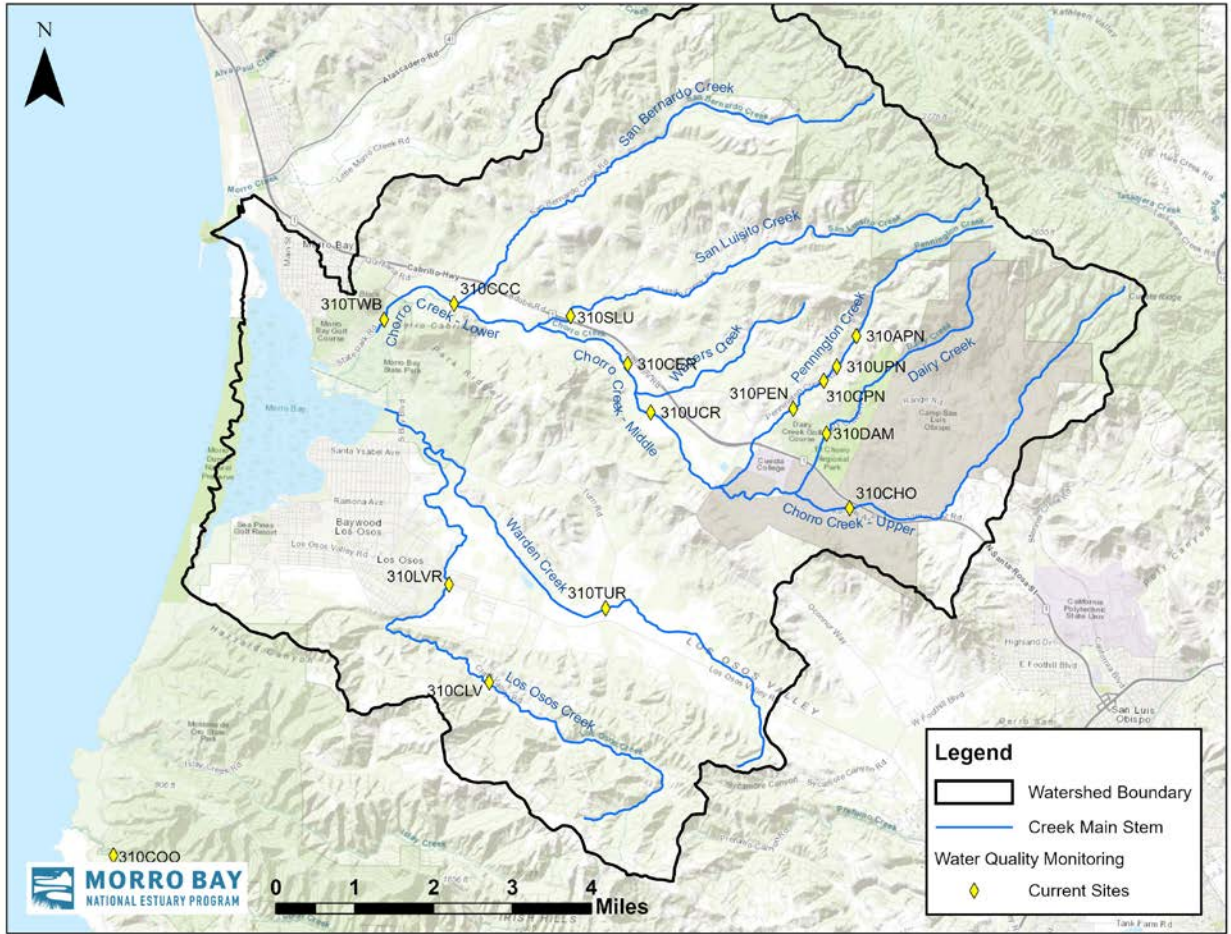


Figure 2: Map of the Estuary Program’s ambient monitoring sites

Outside of storm events, the ambient turbidity levels rarely exceeded the Central Coast Basin Plan levels of concern of 25 nephelometric turbidity units (NTU) for protection of aquatic life in cold water (beneficial use COLD) and 40 NTU in warm waters (beneficial use WARM). Of the 4,156 turbidity readings collected since 2002, 2.2% exceeded 25 NTU and 1.2% exceeded 40 NTU.

Multiple studies have analyzed the accuracy of measuring turbidity as a surrogate for monitoring for SSC or total suspended solids (TSS). Turbidity monitoring is significantly faster and less expensive than monitoring SSC or TSS and has generally proven to be more accurate than other surrogate measures. However, there are limitations to its usefulness in quantifying suspended sediment load in surface waters (Ankcorn, 2003). This being the case, turbidity data collected by the Estuary Program is not used as a predictor of the total sediment load. Additional information on ambient water quality data can be found in the program’s [2022 Creek Health Memo](#).

3.3. Surface Elevation Tables

The U.S. Geological Survey (USGS) monitors sediment deposition in Morro Bay as part of a larger study of sedimentation rates on the west coast. There are four monitoring locations in the Morro Bay salt marsh, including two high marsh and two low marsh sites (Figure 3). USGS established the sites in 2013

and monitors them each year during the dry season (Thorne, 2018). Elevation change is monitored using feldspar marker horizons and surface elevation tables (SETs).



Figure 3: USGS SET and feldspar locations in Morro Bay.

Between 2004 and 2015, the Estuary Program coordinated similar SET and marker horizon monitoring in partnership with the University of San Francisco (USF). Numerous sampling stations were established in the Morro Bay mudflats and salt marsh (Callaway, 2015). Although USF was unable to continue conducting the SET measurements, USGS staff was able to take over the monitoring sites and collected measurements in October 2022. The sites located in the high marsh had an average cumulative elevation change of +0.06 mm and sites in the low marsh had an average cumulative elevation change of +6.75 mm. The rate of elevation change over the course of the study period (2004 to 2022) was 0.46 mm per year in the high marsh and 0.85 mm per year in the low marsh.

3.4. Precipitation and Discharge

In order to better understand the potential for sediment transport in the Morro Bay watershed, the Estuary Program compiles annual precipitation and stage data from a San Luis Obispo County gauging station at Canet Road. Rainfall and stage data from the county-maintained gauges are available for viewing and download from the [County of San Luis Obispo's website](#). This gauging station was

established by the County in 1978, and the Estuary Program established it as an SSC monitoring location in 2007. The site is referenced throughout this report as “Canet” or site code “CAN.”

The Canet Road monitoring station includes a drainage area of approximately 21.8 square miles of the 43-square-mile Chorro watershed and includes flows from the Pennington Creek, Dairy Creek, and Walters Creek tributaries, as shown in Figure 4. The area in the map highlighted in yellow is the area that drains to the Canet gauging station, which collects stage readings at fifteen-minute intervals on a continuous basis.

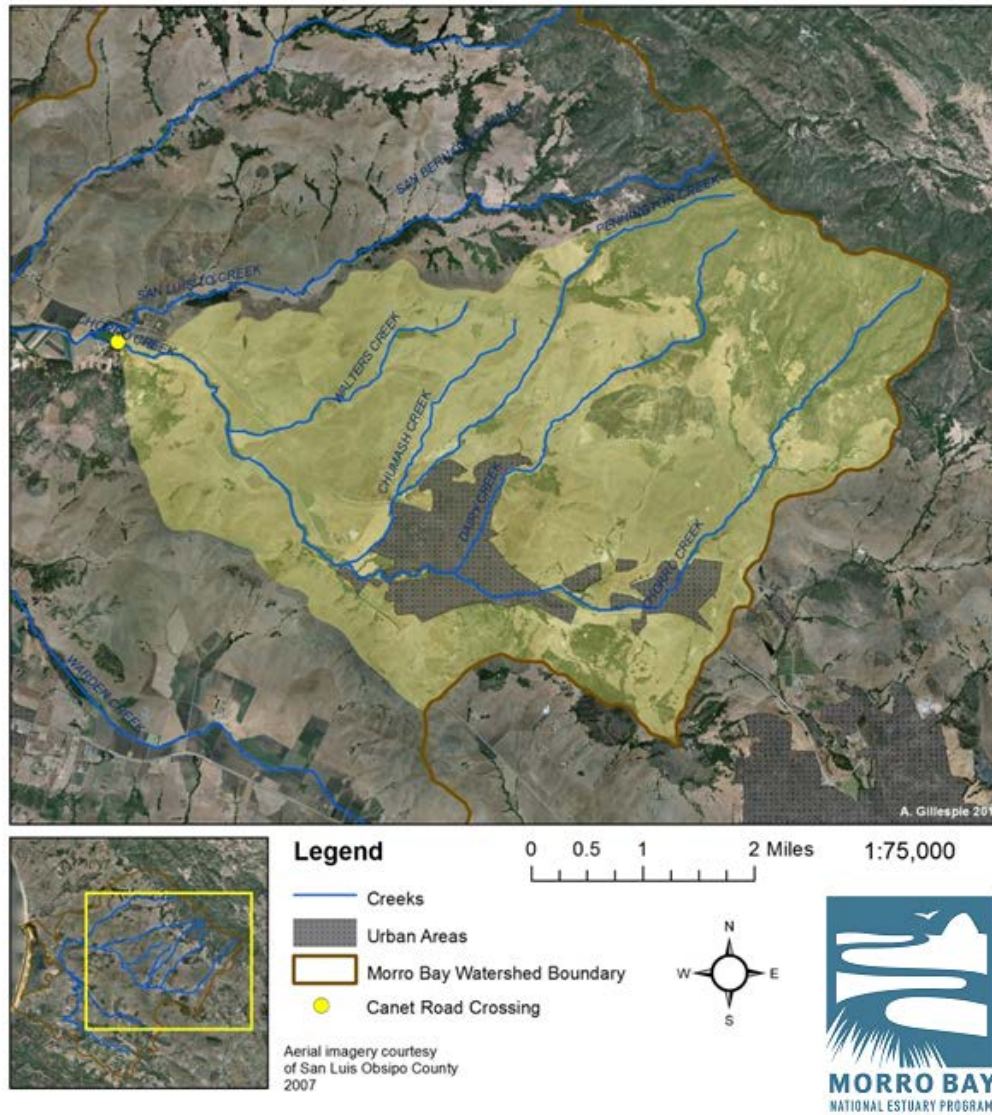


Figure 4: Map of watershed area that drains to Canet Road monitoring site.

In 2010, engineers at Cal Poly’s Irrigation Training and Research Center (ITRC) developed a rating curve to better estimate peak flows at Canet. Analysis of field measurements determined that three unique equations were necessary to approximate flow rates (Q) in cubic feet per second (cfs) at the site depending on stage height, due to the presence of a bridge.

The following equations were used to calculate discharge in this report, and previous versions of this report:

- For stage heights below 12.10 feet, discharge can be approximated by:
 $Q \text{ (cfs)} = 20.907Y^2 - 5.8341Y$
where Y is the depth of water (in feet, recorded by the bubbler gauge) minus channel bottom elevation (3.75 ft) above the reference datum.
- For stage heights between 12.1 feet and 13.2 feet, the discharge is approximated by:
 $Q \text{ (cfs)} = 1200 \text{ cfs}$.
This is the case when the culverts are full, and the water is not overtopping the bridge.
- When the water has overtopped the bridge at heights above 13.2 feet, the following equation is applied:
 $Q \text{ (cfs)} = 1200 + 88 [(H - 13.2) + 0.326]^{2.1}$
where H is the staff gauge reference without adjustment for the channel bottom elevation.

Note that hydrographs generated by the Estuary Program for the Canet Road gauge prior to 2011 used a different rating curve than the rating curve shown above. Therefore, more recent results are not directly comparable with pre-2011 results.

Peak discharge describes the highest rate of flow during a given water year. Review of approximately 40 years of peak discharge data indicates large inter-annual variability in peak discharge at the Canet gauging station, with a range of 7,427 cfs (Figure 5).

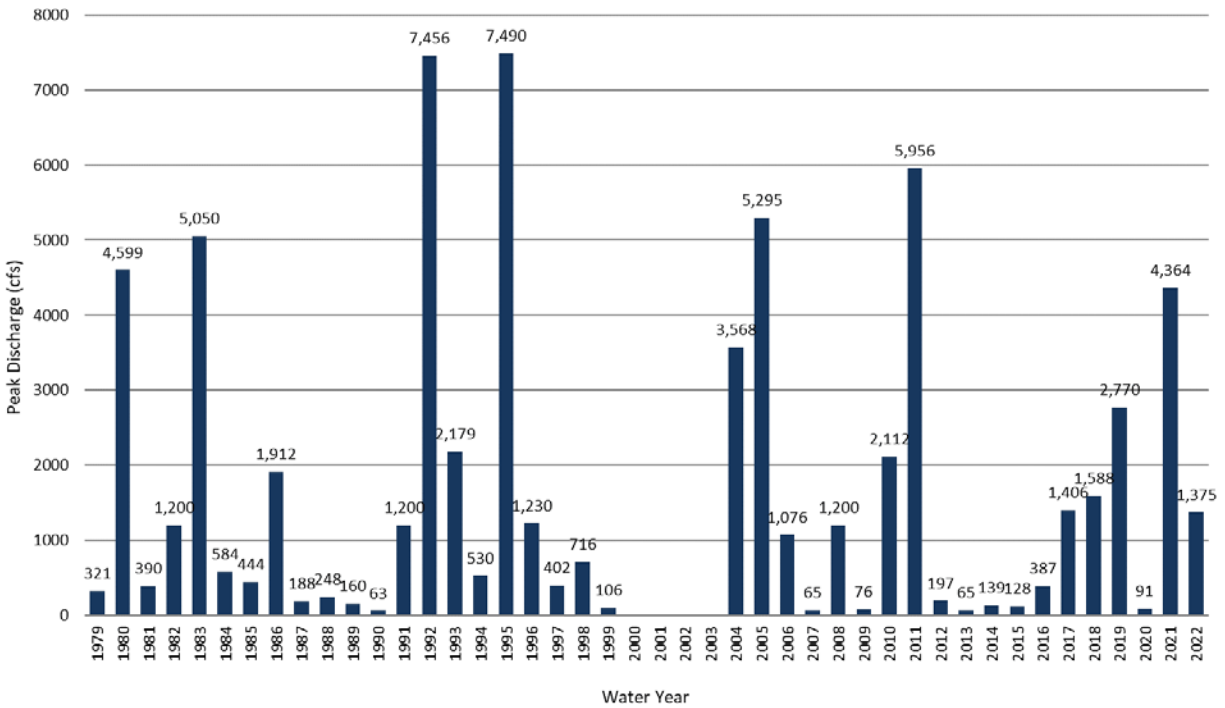


Figure 5: Chorro Creek at Canet Road, peak flow records, from 1979 to 2022.

According to the San Luis Obispo County Department of Public Works precipitation contours, Canet Road receives an average of 20 inches of rainfall per year (Appendix A). The rain contours are a map of the county that describe the expected average annual rainfall for a given area. Table 3 summarizes the rainfall totals from Canet Road from WY 2018 through WY 2022.

Table 2: Summary hydrology statistics for WY 2018 through WY 2022

Water Year	Peak Flow (cfs)	Total Annual Discharge (AF)	Total Annual Rainfall (in)	Percent of 20 inch Average Rainfall
2018	1,587	7,829	13.16	65.8%
2019	1,259	15,581	19.91	99.6%
2020	91.3	6,749	12.27	61.4%
2021	4,364	8,644	11.60	58.0%
2022	1,375	7,885	12.42	62.1%

While the relative magnitude of peak discharge is a function of rainfall intensity and volume (Rankl, 2004), total annual rainfall is not strongly correlated with peak discharge. Figure 6 illustrates the discontinuity between peak flow magnitude and annual rainfall totals.

For example, WY 2017 presents as a high peak on the annual rain total graph (at 25.4 inches) but had a relatively low peak discharge (1,406 cfs). Conversely, WY 2021 had a low annual accumulated rainfall (11.6 inches) but one of the highest peak flows in the last decade. In the case of WY 2017, the rain events were spread out over a longer time period such that they did not result in the type of overland flows that typically contribute the largest inputs of sediment in a surface water system. Thus, annual rainfall totals are unlikely to be a reliable indicator of the relative sediment contribution to Morro Bay in a given year. Previous analyses by the Estuary Program also show that annual rainfall is a poor predictor of suspended sediment loads (MBNEP, 2011).

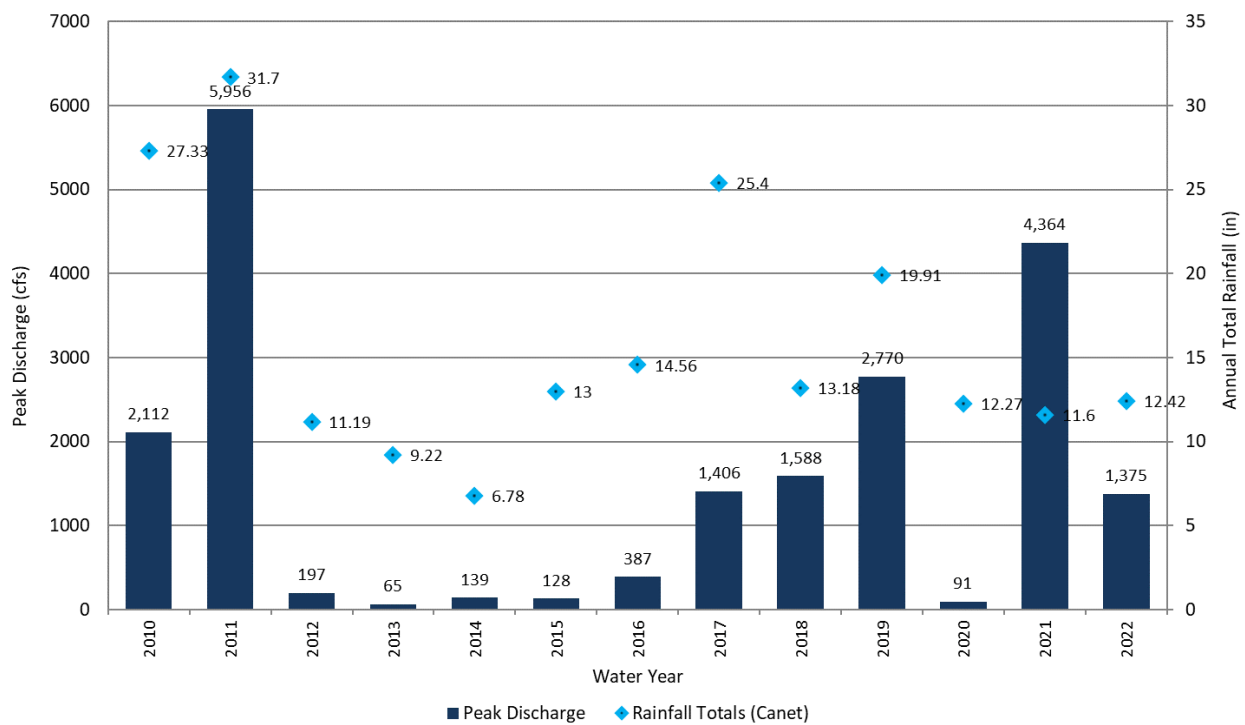


Figure 6: Chorro Creek at Canet Road, peak flow and annual rainfall totals from WY 2010 to WY 2022.

While storm events that generate peak flows are brief when compared to the entire length of the water year, they have dramatic influence on the amount of sediment transported through creeks. Previous analyses have concluded that although rainfall and discharge alone are not strong enough predictors to quantify total load, they can provide valuable insight into sediment transport.

4. Streambed Sediment Impairment Indicators

Since 2002, the Estuary Program conducted bioassessment surveys each spring using the Surface Water Ambient Monitoring Program (SWAMP) protocols. The data collected during these surveys generates

physical and biological metrics that can be used to interpret the impacts of sediment. The Estuary Programs utilizes the physical habitat data collected during bioassessment surveys to compare against proposed sediment indicators developed by the State Water Board and researchers at UC Davis.

While there are no numeric targets for sediment impairment and biological thresholds in the Morro Bay watershed, researchers from the Sierra Nevada Aquatic Research Laboratory (SNARL) have developed targets for the Central Coast and San Lorenzo River region (Herbst, 2011). To develop these targets, numerous indices were tested across a gradient of test sites. The outcome included 16 indicators of sediment impairment on aquatic habitat, including physical characteristics (sediment) and benthic macroinvertebrate community composition. Initial analysis shows that these physical and benthic indicator targets are likely relevant in the Morro Bay watershed.

The current SWAMP bioassessment monitoring protocol (Ode et. al, 2016) generates seven of the nine sediment indicators and six of the seven biological indicators used in the analysis. The indicators that are collected annually by the Estuary Program are bolded in the list below.

Sediment Indicators:

- 1. Percent of Fines (F) on transects**
- 2. Percent of Sand (S) on transects**
- 3. Percent of Fines (F) + Percent of Sands (S) on transects**
- 4. Percent of Fines, Sands and Gravels < 8mm on transects**
- 5. D50 Median particle size**
6. Percent patch-scale grid Fines and Sands
7. Log Relative Bed Stability
- 8. Percent of Fines (Steelhead)**
- 9. Percent Cover of Fines and Sands (BMI Limits)**

Biological Indicators

- 1. Total Richness**
- 2. EPT Richness**
- 3. % EPT**
- 4. Biotic Index**
- 5. Percent Tolerant**
- 6. Sensitive Number**
7. Crayfish Number and Size

For each indicator, there are three threshold criteria for comparison (Table 3). These criteria include targets that are recommended to support beneficial uses, targets that support preliminary low priority 303(d) listing, and targets that support high priority 303(d) listing. In the above list, EPT refers to macroinvertebrate species orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These three orders which are considered indicators of favorable habitat and water quality conditions.

Table 3: Sediment and biological indicator criteria

	Recommended Numeric Targets To Support Beneficial Uses	Recommended Numeric Targets to Support Preliminary 303(d) Listing (lower priority)	Recommended Numeric Targets To Support 303(d) Listing (high priority)
Sediment Indicators		75/25	90/10
Percent Fines on transects	<8.5%	8.5 to 15.2%	>15.2%
Percent Sands on transects	<27.5%	27.5 to 35.3%	>35.3%
Percent Fines + Sands on transects	<35.5%	35.5 to 42.0%	>42.0%
Percent Fines, Sands, Gravel <8mm on transects	<40.0%	40.0 to 50.2%	>50.2%
D50 median particle size	>15 mm	7.7 to 15 mm	<7.7 mm
Percent Fines (steelhead)	<6%	6 to 10%	>10%
Percent cover of FS (BMI limits)	<30%	30 to 40%	>40%
Biological Indicators		75/25	90/10
Total Richness	>50.0	<50.0	<44.2
EPT Richness	>16.5	<16.5	<11.6
Biotic Index	<5.48	>5.48	>5.92
Percent Tolerant	<26.3%	>26.3%	>37.7
Sensitive Number	>9.5	<9.5	<5.8

4.1. Monitoring Sites

The Estuary Program monitors ten bioassessment sites each year based on program data needs, hydrologic conditions, and site accessibility. Sites are designated as “core” or “rotating.” Core sites are monitored every year, and rotating sites are monitored approximately every three years. The six core monitoring sites are included in this sediment analysis.

Five of the six core monitoring sites are located in the Chorro subwatershed, and one is located in the Los Osos subwatershed. The sites within the Chorro subwatershed include Pennington Creek (site code 310UPN), San Bernardo Creek (310MNO), San Luisito Creek (310LSL), Dairy Creek (310DAU), and lower Chorro Creek (310TWB). One site from the Los Osos subwatershed, along upper Los Osos Creek (310CLK) is also included, although no data was collected in 2021 and 2022 due to issues with site access. These monitoring locations are shown in Figure 7.

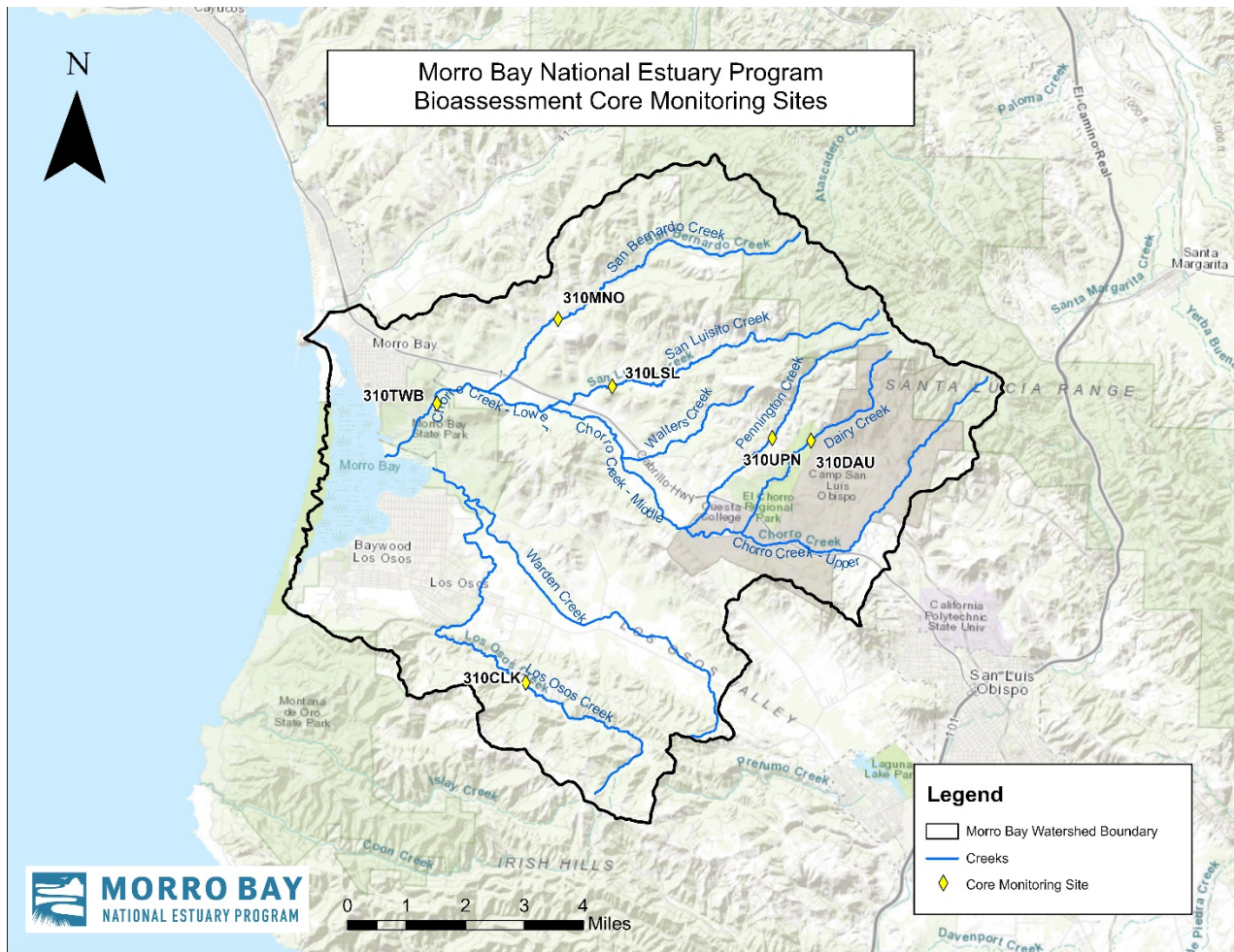


Figure 7: Core bioassessment monitoring sites, including five sites in the Chorro subwatershed and one site in the Los Osos subwatershed.

4.2. Results

Sediment impairment indicator scores were compiled from the six core monitoring sites from 2008 to 2022 (Table 4). The averaged scores from 2008 to 2022 are detailed in Table 5. Scores highlighted in green meet the target criteria for beneficial uses for the given site and year. Scores in yellow show some signs of impairment and would be low priority for 303(d) listing priority, and scores in red are more heavily impaired and strongly support the need for a 303(d) listing.

Table 4: Sediment indicators for core bioassessment monitoring sites from 2008 to 2022.

Site Code	Survey Date	Sediment Indicators							Biological Indicators					
		Percent Fines	Percent Sands	Percent <8mm	FS Sum Percent	D50 Median particle size	Percent Fines (steelhead)	Percent Cover of FS (BMI limits)	Total Richness	EPT Richness	Percent EPT	Biotic Index	Percent Tolerant	Sensitive Number
310MNO	2008	0.0	24.8	26.7	24.8	20.0	0.0	24.8	64.0	20.0	50.4	4.7	9.4	10.0
310MNO	2010	1.0	23.3	30.1	24.3	14.0	1.0	24.3	42.0	14.0	61.8	4.7	7.1	5.0
310MNO	2012	2.9	9.8	14.7	12.8	37.0	2.9	12.8	69.0	22.0	42.8	4.8	8.7	10.0
310MNO	2013	2.9	7.8	18.6	10.8	31.0	2.9	10.8	66.0	18.0	19.0	5.7	9.1	14.0
310MNO	2014	5.0	24.0	35.0	29.0	24.0	5.0	29.0	46.0	3.0	3.4	7.3	17.4	3.0
310MNO	2015	6.7	9.5	24.8	16.2	17.0	6.7	16.2	57.0	5.0	4.3	6.9	14.0	4.0
310MNO	2016	13.5	11.0	36.5	12.4	12.5	13.5	12.4	70.0	16.0	23.6	5.91	14.3	9.0
310MNO	2017	6.7	20.0	34.3	26.7	23.0	6.7	26.7	37.0	12.0	52.7	4.9	10.8	4.0
310MNO	2018	7.6	17.1	30.5	24.8	27.0	7.6	24.8	52.0	19.0	21.2	5.7	15.4	9.0
310MNO	2019	9.5	26.7	46.7	36.2	9.0	9.5	36.2	52.0	17.0	32.2	5.4	5.8	6.0
310MNO	2020	12.4	21.0	49.5	33.3	8.0	12.4	33.3	61.0	14.0	25.9	5.6	14.8	48.3
310MNO	2021	3.8	32.4	45.7	36.2	11.0	3.8	36.2	47.0	11.0	12.2	6.2	21.3	5.0
310MNO	2022	15.2	14.3	29.5	29.5	19.0	15.2	29.5	66.0	15.0	21.4	6.2	15.2	9.0
310LSL	2008	5.7	19.1	33.3	24.8	12.0	5.7	24.8	55.0	14.0	25.2	4.5	12.7	9.0
310LSL	2010	11.8	10.9	33.7	22.8	13.0	11.8	22.8	48.0	18.0	50.7	4.6	6.3	9.0
310LSL	2012	2.9	23.3	32.1	26.2	14.0	2.9	26.2	61.0	22.0	18.3	4.5	9.8	16.0
310LSL	2013	10.5	9.5	25.7	20.0	17.0	10.5	20.0	39.0	4.0	0.9	5.2	15.4	2.0
310LSL	2014	16.2	11.4	34.3	27.6	20.0	16.2	27.6	44.0	8.0	4.3	5.5	9.1	6.0
310LSL	2015	14.4	11.5	37.5	26.0	11.0	14.4	26.0	54.0	14.0	17.8	5.3	9.3	6.0
310LSL	2016	23.8	9.5	40.0	33.3	9.0	23.8	33.3	44.0	15.0	36.0	4.54	8.9	9.0
310LSL	2017	9.8	12.7	27.5	22.5	20.5	9.8	22.5	37.0	12.0	28.8	5.0	13.5	6.0
310LSL	2018	1.9	30.5	32.4	32.4	14.0	1.9	32.4	55.0	22.0	51.4	4.2	7.3	12.0
310LSL	2019	15.5	17.5	47.6	33.0	9.0	15.5	33.0	52.0	19.0	39.7	4.9	7.7	10.0
310LSL	2020	12.4	11.4	39.0	23.8	11.0	12.4	23.8	55.0	15.0	7.7	5.4	7.3	28.2
310LSL	2021	5.8	19.4	33.0	25.2	12.0	5.8	25.2	48.0	16.0	42.4	4.9	10.4	10.0
310LSL	2022	6.9	25.5	36.3	32.4	15.0	6.9	32.4	58.0	17.0	40.8	4.7	13.8	9.0
310UPN	2008	1.9	12.4	20.0	14.3	25.0	1.9	14.3	62.0	17.0	18.4	5.0	9.7	14.0
310UPN	2011	2.9	15.2	19.1	18.1	120.0	2.9	18.1	59.0	25.0	64.4	4.3	5.1	13.0
310UPN	2012	1.0	16.5	17.5	17.5	63.5	1.0	17.5	56.0	21.0	48.5	4.0	8.9	15.0
310UPN	2013	2.9	7.7	14.4	10.6	100.5	2.9	10.6	70.0	24.0	32.6	4.5	5.7	17.0
310UPN	2014	1.9	3.8	9.5	5.7	87.0	1.9	5.7	73.0	20.0	17.6	4.9	6.9	15.0
310UPN	2015	5.8	4.8	16.3	10.6	55.5	5.8	10.6	53.0	10.0	16.1	5.4	9.4	5.0
310UPN	2016	2.9	9.0	24.8	2.9	24.0	2.9	2.9	42.0	3.0	2.9	7.2	21.4	3.0
310UPN	2017	1.0	15.2	23.8	16.2	21.0	1.0	16.2	50.0	15.0	58.4	4.7	6.0	8.0
310UPN	2018	1.9	24.8	29.5	26.7	30.0	1.9	26.7	57.0	21.0	45.0	4.0	3.5	16.0
310UPN	2019	2.9	6.7	16.2	9.5	34.0	2.9	9.5	60.0	16.0	26.4	5.0	6.7	11.0
310UPN	2020	1.0	13.3	19.0	14.3	55.0	1.0	14.3	67.0	20.0	24.9	4.8	9.0	46.0
310UPN	2021	2.9	10.5	19.0	13.3	53.0	2.9	13.3	61.0	15.0	19.7	5.4	8.2	11.0
310UPN	2022	0.0	20.0	21.9	20.0	28.0	0.0	20.0	60.0	17.0	20.7	5.1	8.3	7.0
310TWB	2008	18.8	7.9	31.7	26.7	13.0	18.8	26.7	55.0	14.0	27.3	5.4	14.6	7.0
310TWB	2012	8.0	29.0	44.0	37.0	9.5	8.0	37.0	46.0	8.0	6.8	6.7	21.7	3.0
310TWB	2013	9.7	18.5	44.7	28.2	9.0	9.7	28.2	52.0	9.0	3.7	6.4	21.2	4.0
310TWB	2014	24.8	11.4	53.3	36.2	6.0	24.8	36.2	41.0	4.0	6.9	6.5	24.4	2.0
310TWB	2015	12.5	41.0	59.0	41.0	5.0	0.0	41.0	31.0	0.0	0.0	7.6	29.0	0.0
310TWB	2016	12.4	24.8	51.4	37.1	12.5	13.5	37.1	31.0	9.0	34.1	5.5	19.4	4.0
310TWB	2017	12.5	21.2	34.6	33.7	16.0	12.5	33.7	31.0	9.0	34.1	5.5	19.4	4.0
310TWB	2018	14.3	35.2	63.8	49.5	3.0	14.3	49.5	46.0	11.0	14.6	6.3	17.4	5.0
310TWB	2019	16.3	35.6	63.5	51.9	1.0	16.3	51.9	43.0	10.0	22.8	6.6	18.6	1.0
310TWB	2020	21.0	29.5	66.7	50.5	2.0	21.0	50.5	47.0	9.0	26.7	5.8	19.2	44.3
310TWB	2021	22.9	21.9	46.7	44.8	9.0	22.9	44.8	40.0	6.0	7.4	6.9	17.5	2.0
310TWB	2022	4.2	40.6	46.9	44.8	9.0	4.2	44.8	44.0	8.0	13.4	6.6	22.7	3.0
310CLK	2017	3.9	10.7	19.4	14.6	35.0	3.9	14.6	51.0	8.0	5.0	6.4	15.7	5.0
310CLK	2018	3.8	18.1	31.4	21.9	14.0	3.8	21.9	59.0	10.0	21.6	6.2	17.0	6.0
310CLK	2019	4.8	18.1	25.7	22.9	29.0	4.8	22.9	40.0	11.0	23.4	4.9	10.0	4.0
310CLK	2020	5.7	21.0	40.0	26.7	10.0	5.7	26.7	59.0	15.0	51.8	4.7	11.9	61.0
310DAU	2011	15.7	14.7	33.3	30.4	22.5	15.7	30.4	45.0	13.0	53.5	4.8	4.4	8.0
310DAU	2017	2.9	24.8	32.4	27.6	20.0	2.9	27.6	49.0	11.0	44.8	4.5	2.0	7.0
310DAU	2018	1.0	21.6	25.5	22.5	22.5	1.0	25.7	66.0	22.0	37.8	4.6	7.6	17.0
310DAU	2019	2.9	33.3	38.1	36.2	16.0	2.9	36.2	55.0	15.0	42.6	5.1	10.9	6.0
310DAU	2021	2.9	32.4	42.9	35.2	15.0	2.9	35.2	27.0	6.0	32.2	4.3	7.4	3.0
310DAU	2022	8.9	11.9	22.8	20.8	20.0	8.9	20.8	66.0	16.0	21.2	5.0	9.1	10.0

Recommended numeric targets to support beneficial uses
 Recommended numeric targets to support preliminary 303d Listing (low priority)
 Recommended numeric targets to support 303d listing (high priority)

Table 5: Averages for sediment indicators for core bioassessment monitoring sites.

Site Code	Sediment Indicators							Biological Indicators					
	Percent Fines	Percent Sands	Percent <8mm	FS Sum Percent	D50 Median particle size	Percent Fines (steelhead)	Percent Cover of FS (BMI limits)	Total Richness	EPT Richness	Percent EPT	Biotic Index	Percent Tolerant	Sensitive Number
310MNO	6.7	18.6	32.5	24.4	19.4	6.7	24.4	56.1	14.3	28.5	5.7	12.6	10.5
310LSL	10.6	16.3	34.8	26.9	13.7	10.6	26.9	50.0	15.1	28.0	4.9	10.1	10.2
310UPN	2.2	12.3	19.3	13.8	53.6	2.2	13.8	59.2	17.2	30.4	4.9	8.4	13.9
310TWB	14.8	26.4	50.5	40.1	7.9	13.8	40.1	42.3	8.1	16.5	6.3	20.4	6.6
310CLK	4.5	17.0	29.1	21.5	22.0	4.5	21.5	52.3	11.0	25.4	5.5	13.6	19.0
310DAU	5.7	23.1	32.5	28.8	19.3	5.7	29.3	51.3	13.8	38.7	4.7	6.9	8.5

- Recommended numeric targets to support beneficial uses
- Recommended numeric targets to support preliminary 303d Listing (low priority)
- Recommended numeric targets to support 303d listing (high priority)

Note that the averages in Table 5 are calculated from the values in Table 4.

4.3. Discussion

Preliminary analysis of this data indicates that physical characteristics are variable across sites in the Morro Bay watershed. Certain sites indicate greater levels of impairment than others, especially along the mainstem of Chorro Creek. It is important to note that these results do not include the full suite of sixteen metrics around which the analysis was developed.

Pennington Creek at 310UPN has consistently met all sediment indicator targets since 2008 and has met nearly all targets for both sediment and biological indicators since 2018. With the averaged data from 2008 through 2022 (Table 5), 310UPN also met all numeric targets that support beneficial use. Prior to 2016, San Bernardo Creek at 310MNO supported beneficial uses across the board as well but has since declined in various sediment indicators. Los Osos Creek at 310CLK was not monitored during 2021 or 2022 but has historically met most indicator targets. 310CLK has shown some variability in the biological indicators, with lower scores for EPT Richness but consistently high scores for Percent Tolerant species. Chorro Creek at 310TWB has had several indicators meet the lower priority criteria for 303(d) listing while several other indicators meet the high priority criteria for listing.

These indicator criteria are still being assessed for incorporation in the 303(d) listing process and TMDL assessment process in the Central Coast region. These criteria differ greatly from the D50 and percent sands/percent fines criteria listed in the approved sediment TMDL for Morro Bay. Further guidance is needed from the Water Board for future assessments of the status of the Morro Bay Sediment TMDL.

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Appendix A. San Luis Obispo County precipitation contours

