

2. Introduction to the Morro Bay Watershed

The Morro Bay watershed is 48,450 acres in area, ranges in elevation from sea level to approximately 730 m (2400 feet) at the highest point on the watershed boundary. The north and east boundaries of the watershed consist of foothills and ridges of the Santa Lucia Range. The south boundary is the Irish Hills. A sand spit, connected to the mainland at its southern end, separates the estuary from the Pacific Ocean, except for a narrow inlet at its northern end, and constitutes the western boundary of the watershed. A line of "morros," erosional remnants of ancient volcanoes, subdivides the watershed into two subwatersheds, drained by Chorro Creek on the north and Los Osos Creek on the south. The Chorro Creek subwatershed is about 30,000 acres, and the Los Osos subwatershed is about 18,000 acres. A dendritic drainage pattern dominates the watershed.

About 80 percent of the Morro Bay watershed is underlain by the Jurassic-Cretaceous Franciscan Formation (Hall et al., 1979). The Franciscan Formation is a mixture of sandstone (graywacke), claystone, shale, chert, conglomerate, and a variety of metamorphic rocks including serpentinite. Other lithologies in the watershed include porphyritic dacite, small areas of middle to upper Miocene Monterey Formation (mainly siliceous shales and siltstones), and Quaternary alluvium, dune sand, and landslide deposits.

The Morro Bay watershed is in a Mediterranean climate, with warm dry summers and cool wet winters. Rainfall amounts, by month and season total, for the city of Morro Bay throughout the monitoring period are shown as Table 2.1. The maritime influence is pronounced with moderate temperatures and frequent fogs reaching as high as the Cuesta Ridge. Average temperature is about 12°C (54°F). The average length of the growing season, determined by days between killing frosts, is >350 days at the coast to 300 days on ridgetop of the Santa Lucia Range. Average annual rainfall ranges from 45 cm (18 inches) at the coast to 89 cm (35 inches) on the ridge; most of this rainfall occurs between November and April (sources: Department of Water Resources, 1958; Ernstrom, 1984). 2000/01 and 2001/02 precipitation data are from CIMIS Station 160, San Luis Obispo West.

Table 2.1. Seasonal precipitation data from the El Chorro weather station, located between the paired watersheds in the Chorro Creek watershed.

No entry means no rainfall was recorded for that month.

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
94/95						1.03	14.78	1.11	14.62	0.16			31.70
95/96		0.02	0.02	0.02	0.33	0.14	5.81	7.38	0.86	0.20			14.78
96/97				2.82	4.40	8.03	8.26	0.09	0.02				23.62
97/98							4.92	7.28	0.87	0.20			13.27
98/99			0.03	0.38	1.34	1.06	1.74	2.93	3.78	1.93			13.14
99/00				0.05	1.27	0.02	3.10	9.86	1.39	2.24			17.93
00/01				1.57	0.01	0.20	6.14	5.44	8.87				22.23

Variable geology, topography, and climate within the Morro Bay watershed has ensured that the soils are also quite variable. Most soils within the Morro Bay watershed are in the Vertisols and Mollisols orders - in California, these are typical soils under grasslands in the Southern Coast Ranges. Surface textures are generally fine, including clays, clay loams, and loams, although soils on sand dunes have sandy textures. Soil depths range from shallow, at higher elevations, to very deep, on floodplains, alluvial fans, and sand dunes. Soils on hillslopes are shallow to deep. Most soils are moderately well to excessively drained; a few areas of wetlands, floodplains, and tidal flats are poorly drained (source: Ernstrom, 1984).

Vegetation is also variable, and strongly related to soils and landforms. In general, broad expanses of moderately sloping hillsides support grasslands, with annual and perennial grasses and forbs. Upper slopes of ridges and hills support mixed shrubs. Oaks on upper banks, and willows and shrubs on lower banks occupy some less-disturbed riparian areas.

Riparian habitat exists in corridors along creeks and includes tall overstory trees, shrubby vegetation, and understory grasses and forbs. These areas provide nesting, feeding and cover habitat for a number of birds, mammals, and other species, and serve as wildlife corridors for migratory animals. Chorro and Los Osos Creeks serve an important role as warm and cold freshwater habitat for the spawning, reproduction, and early development of rare, threatened or endangered species of aquatic organisms.

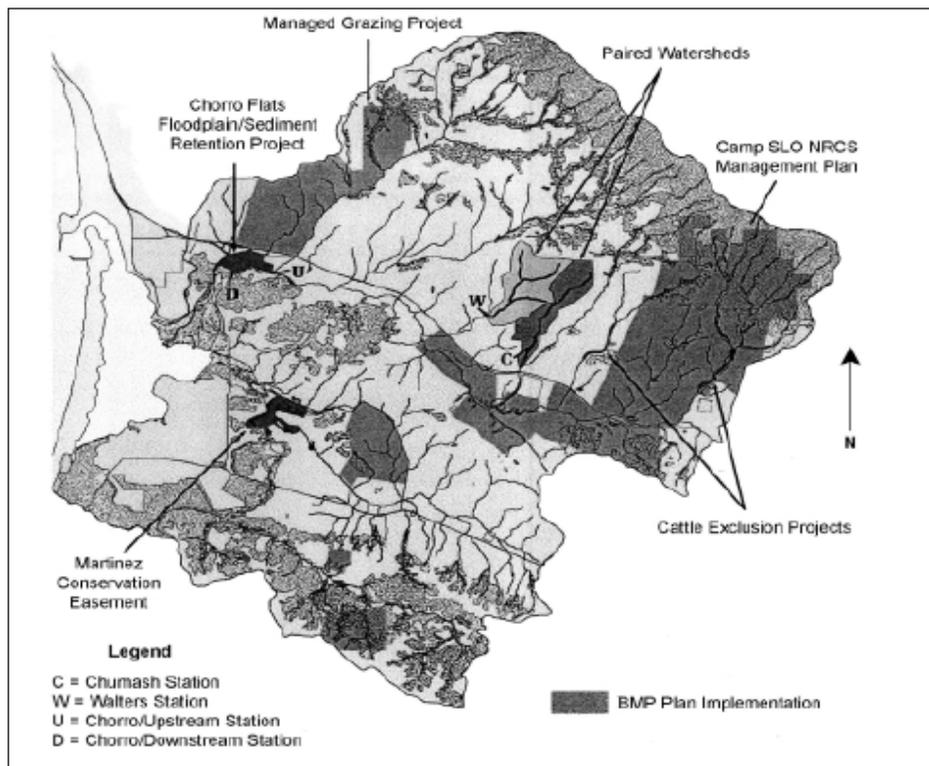
About 50 percent of the watershed consists of agricultural rangeland, 10 percent is in cropland, and 10 percent urban. The Morro Bay watershed includes two urban areas: the city of Morro Bay and the community of Los Osos. Various nonpoint source pollutants, particularly nutrients, sediment, and bacteria, are associated with rangeland, cropland, and urban areas. The remainder of the watershed supports natural habitats including the estuary and associated tidal flats, freshwater marsh, riparian, brushland, and woodland.

The Central Coast Regional Water Quality Control Board (CCRWQCB) and California Polytechnic State University (Cal Poly) have partnered in monitoring various projects within the watershed as part of the National Monitoring Program (NMP). Sources including the Natural Resources Conservation Service (NRCS), the California Coastal Conservancy, and the Coastal San Luis Resource Conservation District, the State Water Resources Control Board, the Department of Transportation, and private and public landowners in the watershed funded implementation of these projects. The paired watershed study at Chumash Creek and Walters Creek has been the focus of the NMP project. Additional BMP evaluation sites that have been implemented and monitored throughout the Morro Bay watershed including Dairy Creek, the upper Chorro Creek watershed, the Maino Ranch, and Chorro Flats. Table 2.2 shows BMP implementation dates and pre-BMP and post-BMP monitoring periods. Figure 2.1 shows study sites.

Table 2.2. BMP implementations dates and pre-BMP and post-BMP monitoring periods.

BMP Project	Pre-BMP Monitoring	BMP Installation	Post-BMP Monitoring
Chumash/Walters Creek	1993-96	1994-97	1996-2001
Dairy Creek	1993-95	1994	1995-2001
Maino Ranch	1993	1994	1995-2000
Upper Chorro Creek	1993-95	1994	1995-2001
Chorro Flats	1993-95	1997	1998-2000

Figure 2.1. Map of the Morro Bay watershed, with monitoring study sites.



2.1 Paired Watershed Study

Two subwatersheds in the Chorro Creek watershed, both on Cal Poly cattle rangelands, were selected for monitoring over a ten-year period. Chumash Creek watershed (400 acres) and Walters Creek watershed (480 acres) are as similar as possible in size, geomorphology, geology, soils, climate, vegetative cover, and land use. They share a common divide, and are managed as cattle rangeland. Both are in the foothills of the Santa Lucia Range. Bedrock geology consists mainly of Franciscan Formation, consisting of sandstone, shale, and limestone with outcrops of chert and serpentinite. Chumash watershed and the divide between Walters and Chumash watersheds include a few outcrops of porphyritic dacite and rhyolite, identical in lithology to the morros and representing parts of the morro "chain." Small areas along creeks consist of alluvium, and low order drainages include small areas of landslide deposits. Soils are mainly fine textured. Vegetation of both watersheds is grasslands with a few areas of shrubs and oak woodland.

Cal Poly owns the land encompassed by Walters and Chumash watersheds. Chumash and Walters Creeks run through Cal Poly's Escuela Ranch, which is a cow-calf operation with approximately 150 cows grazing both creeks' watersheds, plus Pennington Creek watershed (not included in the paired watershed study). The primary goal for the Escuela Ranch is education of Cal Poly's students in proper management of the land and cattle. This is accomplished through various courses that utilize the ranch for laboratory exercises, and the Escuela Enterprise. The enterprise, administered through the Animal Science Department, allows students to lease cattle from the University Foundation and apply technologies and management practices taught in the classroom. The other major goal for the ranch is sustainability. Sustainability is viewed as both improvement of the environment, specifically range and water quality, and profitability of the enterprise. Cal Poly's commitment to these goals assured continuity of land management throughout the monitoring period. Land treatment, including cattle management, is explained more thoroughly in Chapter 3.

2.2 Dairy Creek

Dairy Creek, tributary to Chorro Creek, runs through El Chorro Regional Park, and is the site of a cattle exclusion project. The land was grazed for many years without creek corridor protection, and in many areas the riparian vegetation was severely damaged. NRCS partnered with San Luis Obispo County Parks Department fencing and revegetating the mile-long riparian corridor through the park. Improvements to the lower mile of creek were completed during the summer of 1994, with the remaining upper half-mile of creek fenced during the summer of 1995. In the past, approximately 50 head of cattle grazed on the 750-acre property. The fencing encloses the riparian corridor on both sides of the creek, separating it from the grazing areas. The number of acres available for grazing has been reduced from 750 to less than 400. Of the 750 acres previously grazed, 150 acres have been designated as a botanical area. A large portion of the park was developed as a golf course beginning in 1995 and completed in 1997.

The lower mile of the creek was fenced mid-July, 1994 to protect the creek, improve water quality and to eliminate cattle access to the golf course area.

2.3 Maino Ranch

The Maino Ranch is located at the intersection of Highway one and San Bernardo Creek Road in the Morro Bay watershed. The Maino Ranch is a privately owned, 1850-acre ranch located in the Morro Bay watershed within San Luis Obispo County California. The ranch ranges in elevation from 40 to nearly 1000 feet above sea level. The ranch has several creeks and draws flowing into San Bernardo Creek. The bedrock geology consists of the Franciscan Formation, including a sizeable area of serpentinite. Soils on the ranch are diverse, and surface textures range from loams to clays.

John and Susie Maino own and operate the ranch. They run a cow-calf, commercial beef operation. Cropland on the ranch presently totals 92 acres and is leased out to a local farmer. Typically, the crops grown are snow peas, fava beans, squash, and hay. The ranch has been in the Maino family for eighty-three years. For most of those years it was run as a dairy farm and leased to non-family members. When the Mainos took over the ranch in 1973, he was the first family member to live on and operate the ranch.

2.4 Upper Chorro Creek

Cattle exclusion fencing was installed along the riparian corridor of upper Chorro Creek in 1994. Chorro Creek Dam and Chorro Valley Culvert are the upper and lower sampling stations of a cattle exclusion area on the Camp San Luis Military Reservation.

2.5 Chorro Flats

Chorro Flats, located near the mouth of Chorro Creek, is the site of a floodplain restoration and sediment retention project and was acquired by the Coastal San Luis Resources Conservation District. This \$1.2 million, 120-acre parcel was purchased by a grant from the California Department of Transportation through the California Coastal Conservancy. In the 1989 "Erosion and Sediment Study" conducted by the U.S. Department of Agriculture, Soil Conservation Service (SCS), it was estimated that construction of this project would result in a 33.8% reduction in sediment reaching the bay.

The Coastal San Luis Resource Conservation District (CSLRCD) presently manages the land. The engineering design was completed and project construction was finalized during the summer of 1997. Where the creek was channeled and levied, the project reestablished an active floodplain, riparian corridor, and overflow channels. The majority of the creek flow is now using the newly created main channel.

2.6 Data Management

All water quality related data generated by this project has been stored in the Central Coast Ambient Monitoring Program (CCAMP) database and will be submitted into the

SQWIS/STORET system. In addition, all data that can be accommodated by the framework of the NPSMS will be entered into that system as well. A CD of raw and summary data for the entire NMP project is available at the Regional Board.

2.6.1 Quality Assurance Project Plan

A Quality Assurance Project Plan (QAPP) was prepared that follows EPA guidelines (Worcester et al., 1996). This QAPP accompanied the 1993-94 annual report as a separate document. It included information from both the Cal Poly project team and the Regional Board.

The QAPP was reviewed in 1994 by an independent consulting firm contracted by the USEPA. Comments from the QAPP review were sent to the monitoring team. The QAPP was subsequently revised by Regional Board staff and the Cal Poly team and was returned to the USEPA for final approval. The Final QAPP was approved in September 1995. Copies of this document are available through the Regional Board office. A summary of qa/qc procedures and results are included in Chapter 10.

2.6.2 Public Participation

The Regional Board and Cal Poly have held numerous educational events during the course of the Morro Bay NMP project, including field tours for students and land managers, lectures at Cal Poly, and technical presentations at professional conferences.

The Regional Board and Cal Poly hosted the 7th National Nonpoint Source Monitoring Workshop September 12th – 17th, 1999 at the Inn at Morro Bay. Plenary and concurrent sessions encompassed the theme of the workshop, *Linking Water and Habitat Improvements to Land Treatments*. This annual workshop focused on detecting water and habitat quality improvements resulting from implementation of Best Management Practices both nation-wide and in the Morro Bay watershed. Over two hundred land managers and water quality experts from around the nation participated in the workshop.

Cal Poly and the Regional Board prepared technical reports of the preliminary results annually. The Project Team met numerous times each year to discuss the status of the project, and resolved any changes that needed to occur regarding study design or project tasks. A Technical Advisory Committee (TAC) was convened to review and provide input into the Morro Bay NMP Draft, Revised Draft, and Final Reports. Additionally, the TAC guided the development of a Fact Sheet of Final Results and the project's website. The TAC met several times during the final year of the project.

2.7 Watershed-Wide Characterization

In addition to the water quality data collected at the BMP evaluation sites, data was also collected from several other locations throughout the Chorro Creek and Los Osos Creek watersheds during 1993-2001. These sampling stations were used to collect watershed-wide data for use in targeting and prioritizing areas for BMP implementation and to monitor various projects that are already occurring throughout the watershed. Table 2.3 shows all monitoring locations (including BMP evaluation sites discussed previously) and the monitoring approach that was used each year. A key is included below.

Table 2.3 NMP monitoring locations and approach by water year.

site name	site tag	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001
Above Chorro Reservoir	ACD		B	B	B				
Chorro Reservoir Outlet***	CHD (UCH)	E/O/B	E/O/B	E/O/B	E/O/B	E/O	E/O/B	E/O	E/O/B
Chorro Valley Culvert***	CVC (LCH)	E/B	E/B	E/B	E/B				
Camp San Luis Obispo	CSL	E	E	E	E	E	E	E	
Chorro Creek @ Highway 1	CHW								E?
Dairy Creek Lower**	DAL	E	E	E	E	E	E	E	E
Dairy Creek Upper**	DAU	E/B	E/B	E/B	E/B	E	E/B	E	E/B
Dairy Creek Middle**	DAM	E/G/B	E/G/B	E/G/B	E/G/B	E/G	E/G/B	E/G	E/G/B
Pennington Creek**	PEN	E/G/B	E/G/B	E/G/B	E/G/B	E/G	E/G/B	E/G	E/G/B
Chumash Creek *	CHU	E/S/G	E/S/G	E/S/G/B	E/S/G/B	E/S/G	E/S/G/B	E/S/G	E/S/G/B
Walters Creek *	WAL	E/S/G	E/S/G	E/S/G/B	E/S/G/B	E/S/G	E/S/G/B	E/S/G	E/S/G/B
San Luisito Creek	SLU	E/C	E/G?						
San Bernardo Creek @ Maino Ranch	MNO	E	E	E/O?	E/O?	E	E	E?	
San Bernardo Creek	SBE	E/C	E/C	E/C	E/C?	E	E	E	E/G?
Chorro Creek @ Canet Road	CAN	E/C	E/B						
Chorro Creek @ Chorro Creek Road****	CCR (UCF)	B	O?	B	E/B	E	E/B	E	E
Chorro Creek @ Old Twin Bridges****	TWB (LCF)	E/B	E	E/B	E/B	E/G?	E/G?/B	E/G?	E/G?/B
Los Osos Creek @ Los Osos Valley Road	LVR	E/C	E/C	E/C/B	E/C	E/C	E/C	E/C	E/C
Warden Creek @ Turri Road	TUR	E	E	E/B	E/B	E	E/B	E	E
Warden Creek	WAR	E	E	E	E	E	E	E	
Los Osos Creek @ Old Santa Ysabel Road	SYB			E	E	E	E	E	
Los Osos Creek @ Clark Canyon	CLK			B	B		B		
Coon Creek in Montan de Oro	COO				B				

S = Storm-Event Water Quality; *E* = Even-Interval Water Quality (see methods for parameters measured at each site)

B = Benthic Macro-Invertebrate (annually); *P* = Stream Profile (annually)

Flow:

C = County Gage Station; *G* = Gurley Meter; *O* = Other Flow Measurement (see methods sections)

BMP Evaluation Sites:

* paired watershed; ** Dairy Creek Project; *** Chorro Creek Project; ****Chorro Flats Project