Morro Bay National Monitoring Program:
Nonpoint Source Pollution and Treatment Measure Evaluation for the Morro Bay Watershed

1992-2002
FINAL REPORT

Prepared for the
U.S. Environmental Protection Agency

on
August 31, 2003

by the

Central Coast Regional Water Quality Control Board

and the

California Polytechnic State University, San Luis Obispo

Morro Bay National Monitoring Program:
Nonpoint Source Pollution and Treatment Measure Evaluation for the Morro Bay Watershed

FINAL REPORT
1992-2002

Prepared for the
U.S. Environmental Protection Agency

August 31, 2003

by the
Central Coast Regional Water Quality Control Board

Katie McNeill (Project Manager)
John H. Davis IV
Karen Worcester
with contributions from Dave Paradies

and the
California Polytechnic State University

Lynn E. Moody (Project Director)
Brian C. Dietterick (Co-Director)
Jonathan Beckett (Co-Director)

James P. Daly
Brent G. Hallock
Becky Judge
Robert K. Smidt
Linda S. Shotwell
Craig Stubler
Peter Meertens
with contributions by
Maria Malkin, Corinne Lindbeck-Vaught, and Allyson Young

Acknowledgments

The Morro Bay NMP Project Staff would like to acknowledge the contributions of the many Cal Poly students who helped with sample collection, range and stream analyses, laboratory analyses, data analyses, and report production, whose names do not appear on the title page. Data collection and gauging station maintenance proceeded with their hard work and dedication. They are listed below:

Jeremy C. Addison
Dawn Afman
Brooke Akers
Douglas L. Allen
Paul Anderson
Read L. Anderson
Stephanie M. Arnold
Stephen A. Austin
Alyson Aquino

Matthew Ballmer
Richard D. Basala
Russell A. Berkowitz
Maria Blanco
Muriel L. Boerboom
Michael R. Brannagan
Joy Brinkerhoff
Jeanne L. Brown
Christopher Burdick

Louis J. Cappel
Mark L. Carpenter
Matthew M. Carpenter
Ben Carter
Mark Chiaramonte
Keven Ann Colgate
Alexis Connelly
Verconica Corella
Timothy S. Craig
Blake F. Cullimore
Adrian Cuzick

John H. Davis IV
Jay P. DeJesus
Benjamin J. DeLiema

Jen Eismeier
Eric Elder

Douglas A. Emerson
David J. Emmons
R. Scott English

Daniel M. Feuerstein
Peter L. Fisher
Alaina Frazier

James A. Gabel
Joel Garcia
Steven M. Gerlach
Brendan Gilbride
Matthew G. Griffin

Cheryl L. Hall
Michael C. Hamilton
Jason D. Hanchett
Kari Harrison
Tiffany Hayes
Jeffrey M. Higbee
Staci L. Holbrook

Darren Jacobsen
Charley Johnck

Laurel A. Karren
Brian Kelly
Constance Kessler
Holly A. Killion
Brian G. N. King
Claire Knopf
Scott Kope
Todd W. Kraemer
Kathryn Kropp
Eric K. Krusee

Jeff D. Langman
Lisa A. Langs

Tish K. Lesvesque
Corinne A. Lindbeck
Karla N. Logue
Chris Long
Matt Luck

Blas C. Martinez
Matt McCarthy
Michael E. McGovern
Cari R. McKay
Ryan McKee
Matthew A. McKinney
Peter Meertens
Andrea Miller
Cynthia E. Mitchell
Devin A. Mody

Alex M. Naughton
Jessica Nelligan
Carrie A. Neubert
David M. Nicholson
Jan Novak

Anthony T. O'Geen
Keith E. O'Neill
Lynelle Onishi

Darcy Parker
Christopher L. Peters
Janet K. Poncelet
Paul W. Prange
Tina Piazza
Bryan M. Price
David W. Price
Jennifer M. Puttere

Jason B. Rainwater
Joseph A. Ramos

Trevor D. Rebel
Jeffrey Reimer
Darryl R. Roberts
Cecile Rogers
Christopher Rose
Julie A. Seely
Audrey E. Senelly
Marne Settera
Daniel S. Seymour
Eric M. Shiers
Linda S. Shotwell
Robert L. Sloan
Jason C. Smith
Kelly Smith
Deno M. Soria
Thomas J. Stewart
Joan M. Stevens
Nichole L. Stockdale
Craig P. Stubler
Robert Tanner
Joseph Thien
Marc H. Tran
Robert E. Tyzzer
Laura Unrue
Keith E. Wales
Jasmine Watts
Daryl Witmore
Richard A. Williams
Ryan B. Williams
Regina S. Wilson
Zhang Yi
Allyson Young
Kim Zangmeister

Throughout the duration of the project, Craig Stubler has been one of the most productive employees, first as a student assistant, then as a Research Associate. Literally, the project could not have proceeded without Craig's involvement in maintenance of the watershed and gauging stations, the collection of water quality samples and data, and data management. In the final two years of the project, Allyson Young has been of inestimable aid in rangeland data collection, and especially in rangeland and stream channel data management and formatting.

The Morro Bay NMP Project Staff would particularly like to thank Elaine Ramos-Doyle and Joyce McAlexander for invaluable administrative support. Joyce, in particular, has been of inestimable help in budget management and contract administration. We are grateful to Susan Tonik for her help in administration of the Agricultural Research Initiative grant, which made up our Contractor's Match during the final two years of the project. The Regional Board would also like to acknowledge the dedicated Cal Poly faculty who volunteered hours on the project.

Cyndee Jones and Carrie Fauset of the Regional Board, Kathy Alameda and Pamela Parker of the State Water Resources Control Board, and Cheryl McGovern of the U.S.E.P.A have also been very helpful in the administrative aspect of this project.

The Morro Bay NMP Project Staff would also like to extend great thanks to John Maino, Steve Soderstrom, John Swift, and Joe Guidetti and their families for granting access to their properties to evaluate the effectiveness of BMPs. The Team also wishes to thank the Natural Resources Conservation Service and the Coastal San Luis Resource Conservation District, the State Water Resources Control Board, and the California Coastal Conservancy for funding BMP implementation and matching funds.

The Morro Bay NMP Project Staff would also like to thank Joy Fitzhugh of the Farm Bureau, and Malcolm McEwen of the Natural Resources Conservation District, for there partnerships and assistance with outreach to the agricultural community.

This successful progress of the many components of the Morro Bay NMP project is due to the continual efforts of numerous staff and volunteers. The data collected for this project would not have been possible without the dedicated efforts of Al Pardo and Bill Moore, and all the Volunteer Monitors. The Regional Board project staff would also like to thank the benthic macroinvertebrates, including the many toe-biters, who dedicated their lives as part of this project.

The Morro Bay NMP Project Staff also wishes to thank the Morro Bay National Estuary Program and the Bay Foundation of Morro Bay for assisting with the 1999 NMP Workshop in Morro Bay, and for providing funding for travel to other annual workshops. Regina Wilson's contributions to the NMP and the volunteer monitoring program are also greatly acknowledged. Ann Kitajima of the Friends of the Estuary has been extremely helpful in establishing a sustainable volunteer monitoring program that will continue data collection at the NMP sites. The project staff also wishes to extend thanks to Mike Multari and Bill Hoffman for disseminating the results of the project.

The Morro Bay NMP Project Staff also wish to thank Wade Baker, of the California Men's Colony Water Treatment Plant and John Waddell, of the San Luis Obispo County Engineering Department, for providing invaluable flow records.

The Regional Board's Monitoring Unit Supervisor Karen Worcester, and Dave Paradies, volunteer for the Central Coast Ambient Monitoring Program, have been fundamental to the project, as they have provided expert guidance, and specialized data management and analysis tools. We also wish to thank Heather Smith and David Wright for developing the statistical models to detect water quality changes. The water quality group staff at the North Carolina State University have also offered invaluable statistical assistance and funding to travel to the annual workshops.

Regional Board Watershed Assessment Unit Supervisor, Lisa Horowitz-McCann, has created a coordinated environment to complete the Morro Bay NMP project, thus ensuring an effective approach in monitoring and managing the watershed, and in using the NMP data to develop Total Maximum Daily Loads for the Morro Bay watershed. Julia Dyer of the Regional Board staff, has been invaluable in data management and in implementing the quality assurance protocols set forth as part of the project.

Lastly, the Morro Bay NMP Project Staff wish to extent a special thanks to all of the members of the NMP Technical Advisory Committee that have not already been mentioned, for directing and reviewing the development of this document.

We apologize if we have forgotten to mention anyone's name. Your assistance is greatly appreciated.

Executive Summary

Morro Bay is located on the central coast of California and supports a variety of marine habitats, commercial and sport fishing, shellfish harvesting, and recreational activities. It is one of California's least disturbed estuaries. The watershed draining into the estuary includes two urban areas, cropland, rangeland, and a variety of natural habitats including marsh, oak woodland, riparian, and dunes. Chorro and Los Osos Creeks are the major streams flowing into Morro Bay. In 1993, the United States Environmental Protection Agency (USEPA) selected the Morro Bay watershed for a ten-year program of water quality monitoring and evaluation of Best Management Practices (BMPs). The Morro Bay estuary was designated a National Estuary in 1995. The watershed is about 48,450 acres in area, and ranges from sea level to 730 meters in elevation. Varied geology and rugged topography contribute to a variety of soils and plant communities. The watershed and estuary are in a Mediterranean type climate, with warm dry summers and cool wet winters.

The watershed and estuary have been impacted by pollutants including sediment, bacteria, metals, and nutrients, originating from cropland, urban areas, rangeland, abandoned mines, eroding streambanks, poorly maintained roads, and other sources. These pollution sources are nonpoint, meaning diffuse in origin. Sediment has been of particular concern. A comprehensive study in the late 1980's estimated that 25 percent of the estuary's volume has been lost to accelerated sedimentation during the past century, and at that sedimentation rate, the bay could be lost as an open-water estuary within 300 years.

In view of the impact of nonpoint source pollution on the estuary, the Central Coast Regional Water Quality Control Board managed a National Monitoring Program, funded by the USEPA's Section 319 (h) of the Clean Water Act. This monitoring study involved several public agencies and private individuals, in implementing BMPs aimed at reducing nonpoint source pollution in the watershed. The goals of the study were to monitor the impacts of selected BMPs on water and habitat quality in the Morro Bay watershed. The project focused on:

- Characterization of sedimentation and water quality conditions in a portion of the Chorro Creek watershed, through sediment and water sample analysis in a paired watershed study.
- Evaluation of the effectiveness of a set of BMPs in improving water and habitat quality in one of the paired watersheds.
- Evaluation of the effectiveness of systems of BMPs in improving water and habitat quality in several locations in the Chorro Creek watershed.
- Evaluation of overall water quality at selected sites in the Morro Bay watershed to establish a database, prioritize problem areas, and aid in future monitoring efforts.
- Evaluation of hydrologic and water quality indicators to document the health and stability of selected streams in the Morro Bay watershed through annual monitoring practices.

This nonpoint source monitoring project is one of very few on the west coast of North America, and the only study of its kind supported by the USEPA at the time of this writing. The diversity of studies addressing the Morro Bay watershed, the Mediterranean climate with its strong seasonal rainfall distribution, and the predominance of agricultural rangeland use, all combine to make this study unique among Section 319 projects in the United States.

Chumash and Walters Paired Watershed Study

Introduction

The monitoring effort included a paired watershed study. Walters and Chumash Creek sub-watersheds were chosen for the paired watershed study because of their similarities in size, aspect, slope, elevation, soils, climate, and vegetation. The Walters Creek watershed is 480 acres; Chumash Creek watershed is 400 acres. They are adjacent. Aspects are southwest, elevations range from 300 to 700 feet. Vegetation is mainly introduced annual grasses with scattered stands of native perennial grasses. Land treatment measures (BMPs) were installed in Chumash watershed, Walters remained the control. Both watersheds are rangeland, used for cattle grazing. Both are owned by California Polytechnic State University and are managed as the Escuela Ranch. Continuity of ownership and management was critical to the goal and objectives of the paired watershed project.

Land Treatment Measures

The Escuela Ranch contains Walters, Chumash, and one other sub-watershed (Pennington Creek watershed, not included in the paired watershed study). The grazing method utilized on the ranch is classified as rest/rotational grazing. The paired watershed study is a comparison between rest/rotation and rest/rotation, with the treatment consisting of smaller pasture size, and more numerous pastures, in Chumash - thus more total rest in Chumash. The cowherd is primarily Angus based, and the breeding decisions are based on consistency, desirable carcass characteristics, and rapid growth. Feed supplementation is used as needed during the last trimester of gestation and the first month of lactation depending on rainfall and forage availability.

When water quality, range, and stream data collection began in 1993, the Walters watershed had four pastures ranging in size from 131 acres to 311 acres. This pasture design has not changed throughout the study and acts as a control with fewer large pastures. Therefore, when cattle graze in this watershed, they graze more time in each pasture and each pasture gets less rest during each rotation.

In 1993 the Chumash watershed was subdivided into only two pastures of 287 acres and 290 acres. By the end of 1995, most of the division of the two original pastures into 14, with some traditional barbed wire fencing, but mainly electric fencing was completed. In 1996 and subsequent years cattle have been rotated through 14 pastures in the Chumash watershed ranging in size from 15 to 130 acres with most of the pastures between 25 and 68 acres. Two of the 14 pastures were established as riparian pastures that are only

grazed one to three days per year and only during the dry season. Cattle spend less time in any single pasture with more rest for each pasture.

The BMPs fell within four categories of rangeland management practices: livestock fencing and water development, streambank stabilization, road improvement, and grazing management. Each BMP category contains individual BMPs that were intended to address the sources of nonpoint source pollution (Shotwell, 2000).

Analysis of variance (ANOVA) was used to determine if grazing days, rest days, and animal unit day (AUD) per acre were truly different, between Walters and Chumash watersheds. There appeared to be an increase in the animal unit days per acre in the treatment watershed, although this trend was not statistically significant ($p>.05$). The increase in AUD/acre suggests an increase in productivity due the implementation of BMPs. The number of days grazed was significantly different ($p>.05$), by treatment. Pastures in the Chumash watershed had fewer average days grazed compared with pastures in the Walters watershed. No real effect on the cattle of the intensive grazing rotation has been shown. This result is because the same cattle are grazed in both of the paired watersheds.

A preferred experimental design would have maintained two separate watersheds, with each containing its own identical, randomly selected herd of cattle. In this design, supplemental feed would be differentially determined between watersheds, and the water quality and rangeland results would be more easily transferable to other ranches.

Event-Based Climate, Streamflow, and Water Quality

Water quality and streamflow were monitored with instrumented gauging stations installed at the outlet of each paired watershed. Gauging stations were installed at a location in each stream channel to allow collection of comparable and representative continuous streamflow and water quality samples (Price and Tyzzer, 1993). Climate data were measured at a centrally-located weather station representative of average conditions for the paired watersheds.

Event-based water samples were collected every 30 minutes by Sigma automatic samplers during storm events that generated sufficient runoff to submerge the instream sampling intakes. Paired event-based water quality samples from Chumash Creek and Walters Creek watersheds were analyzed for turbidity, electrical conductivity, and suspended sediment concentration following USEPA procedures.

Examination of paired hydrographs from 1995 through 2001 revealed interesting trends. In the period of 1995 through 1998, the timing of peak flow in Walters and Chumash was approximately equal. Beginning early in 1999, peak flow of Chumash lagged behind that of Walters, by 30 minutes to 1 hour. This was most noticeable early in each post-BMP season. We hypothesize this was due to increased interception of water by plants, and increased infiltration in the Chumash watershed, as vegetation increased on streambanks and in the watershed.

As of the 2000-01 season, the complete data set contained 82 events that included paired data on turbidity, and 80 events that included paired data on sediment. Significant declines in turbidity and sediment in Chumash Creek were found, as a result of implementing BMPs. Improvements have leveled off, or plateaued, beginning with the 1999-2000 sampling season. We hypothesize that the plateau occurred because fast-growing stream channel vegetation has reached its maximum protective affect, and slow-growing vegetation (such as sycamores and oaks) has not yet reached a stage of maturity where it is having a quantifiable affect on water quality.

Even-Interval Streamflow and Water Quality

In addition to storm-event sampling, even-interval water quality sampling began on Chumash and Walters Creeks in 1993 and was conducted for twenty weeks during winter and spring through 2001. Water quality parameters including pH, conductivity, dissolved oxygen, and water temperature were measured year-round using a hand held multi-functioning water quality meter. Grab samples were also taken year-round for total and fecal coliform bacteria, nitrate and phosphate, and were sent to the Regional Board contract laboratory for analysis. Suspended sediment samples were taken during the winter months and analyzed at Cal Poly's laboratory.

Results of even-interval water quality monitoring indicate that BMPs significantly lowered water temperature at Chumash Creek, when compared to Walters Creek. The number of fecal coliform bacteria exceeding the threshold did not significantly change during the entire study period. This is possibly due to grazing in the upper Chumash watershed or an increase in birds and wildlife. Nitrate exceeded the threshold value (0.300 mg/L) more often at Chumash Creek than at Walters Creek. The decrease in nitrate did not occur post-BMPs, but did change in a way indicative of early riparian succession at Chumash Creek. Dissolved oxygen significantly decreased at Chumash Creek, but became less variable. It should be noted that nitrate and dissolved oxygen values are now more typical of other healthy creeks in the Morro Bay watershed.

Even-interval turbidity samples also exceeded threshold values (7 NTUs) more often at Chumash Creek than at Walters Creek post-BMP. The increase in turbidity during low flow periods may possibly be related to an improvement in overall habitat quality, and the increased plant growth and decay associated with the dynamically changing riparian plant community. Turbidity collected during storm events (as discussed previously) decreased as a result of BMPs, as most sediment is transported during storm events.

Rangeland Vegetation

Vegetation transect monitoring was conducted to document changes over time, in plant composition and biomass. Vegetation monitoring included identification of species, total dry matter (biomass), and percent cover (standing vegetation, persistent litter, nonpersistent litter, and bare ground).

When transect pairs were compared, statistical significance was very poor. With treatment as the only predictor variable, no differences between Chumash and Walters were significant. With covariables, very few differences were significant.

Poor statistical results primarily were due to low number of observations - 2 to 3 years pre-BMP, 6 years post-BMP. Also, the number of variables besides treatment, only a few of which were factored into the regression analyses, is considerable. These would include soil water holding capacity which itself depends on many factors, subtle differences in rainfall distribution between the watersheds, other climatic factors such as temperature and wind, topographic factors such as slope and aspect, and the experience and expertise of data collectors. Pairing the transects was an attempt to eliminate variables related to soils and topography; however, natural physiographic variations make it impossible to find truly identical pairs with this type of study design.

In spite of the lack of statistical significance, the visual impact of Chumash post-BMP implementation, and especially when compared to Walters, is visually striking, especially in stream corridors of Chumash Creek. Stream channels in Chumash are re-vegetating with herbaceous plants and willows on the channel bottoms, and herbaceous and a variety of woody plants on banks. Cattle trails along the streambanks are revegetating. Streambank slump scars are revegetating. On rangeland away from streams, decreases in bare ground have been documented in Chumash and are visually evident, even though these improvements were not statistically significant.

Stream Channel Evaluations

Four permanent paired reaches on each of Walters and Chumash creeks were characterized, in late fall and late spring. The reaches were paired between watersheds, based on similarities in shape, vegetative composition, width, total drainage area, type of stream, stream order, branching, and position. Pfankuch channel stability evaluations were conducted on each of the permanent reaches throughout the monitoring period.

Stream channels showed only minor alterations during the monitoring period, including bank erosion, and channel bottom infilling and downcutting Average Pfankuch ratings for Chumash decreased somewhat post-BMP, suggesting that BMPs have been effective in improving stream stability. The improvements were not statistically significant, however.

Forage Quality

During the sixth year of monitoring, it was noted that the BMPs implemented in Chumash watershed seem to have resulted in an increase in residual vegetation that is harvested by cattle during the dry season. Supplemental feed costs have decreased, and we hypothesized that the grazing practices in Chumash watershed contributed to the increase in vegetation and decrease in supplemental feed costs. In 1999, Cal Poly added a study designed to determine the quality of the nutrition that is contained within the forage in order to determine whether there is a net increase in total nutrients due to the implementation of the BMPs.

Measures of forage quality differed by season, but not by treatment or year. If nutrient contents were affected by implementation of BMPs (specifically grazing practices), they would have been detected by the end of the trial. Since differences were not detected in

the last 3 years, the decision was made to not continue testing earlier samples. Further, it was felt that since a primary plant component (fiber) was not affected by implementation of BMPs, differences in crude protein were very unlikely.

Conclusions

NMP project staff have detected changes due to BMP implementation at Chumash Creek, particularly significant reductions in sediment and turbidity during storm events and improvements in water temperature year-round. This is particularly meaningful because the Cal Poly ranches get more rest than a typical working ranch. Cattle used in the project graze both the paired watersheds included in the study as well as an additional watershed (Pennington Creek) not part of the study. If implementing BMPs improved water quality on an already well-managed land, then it would help improve water quality on other, more traditional ranches.

Dairy Creek BMP Evaluation Project

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. Natural Resources Conservation Service partnered with San Luis Obispo County Parks Department and the Guidetti Family, the historical owners of the Dairy Creek Ranch. BMP implementation included fencing a mile-long riparian corridor through the park and revegetation of the floodplain.. 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.

BMPs significantly improved water temperature and dissolved oxygen and total coliform bacteria. BMPs did not significantly change fecal coliform bacteria, nitrate, ortho-phosphate, and turbidity.

Chorro Creek BMP Evaluation Project

Chorro Creek Dam (CHD) and Chorro Valley Culvert (CVC) are the upper and lower sampling stations of a total cattle exclusion area on the Camp San Luis Military Reservation. Fencing was installed along the riparian corridor of upper Chorro Creek in 1994. This pair of sampling stations was established to examine changes in water quality as the stream moves through the cattle exclusion area.

Water temperature and dissolved oxygen have significantly improved post-BMP implementation at CVC, the treatment site, when compared to CHD, the control site. Fecal coliform has also significantly decreased at CVC, as a result of BMP implementation. The significant reduction in fecal coliform at this BMP evaluation project is most likely due to the fact that there is no cattle access to the creek via water gaps or riparian pasture, as there is with the other projects.

The Maino Ranch Project

The Maino Ranch is a privately owned, 1850 acre ranch in the Morro Bay watershed. The Maino family established a partnership with the Natural Resources Conservation Service (U.S. Department of Agriculture). Funds provided under a cost share agreement allowed installation of new fencing and development of water resources. These modifications were made for the purpose of controlling cattle movement through smaller pastures, provided with water, in intensive grazing rotation/rest system.

Permanent range and stream transects were established in 1993. Data were collected from fall 1993 through spring 2001. Vegetation monitoring was conducted in the spring and in the fall. Spring season monitoring occurred after the rainy season and during the flowering and seed set life stage of the majority of rangeland vegetation. Generally, this was in the interval between May and July, inclusive. Spring season monitoring measured species diversity, plant height, nonfoliar cover, and biomass. The Pfankuch stream stability rating system (Pfankuch, 1978) was used to evaluate reaches included in the study area.

General vegetative species trends were as follows:

- grasses remained dominant
- percent cover of annual ryegrass decreased
- percent cover of brachypodium and soft chess brome increased
- rattail fescue appeared in later years when it had not been previously documented
- Harding grass decreased in the upper ranch but appeared on serpentinitic soils, where it had not previously been seen
- fall biomass has decreased since 1996
- nonpersistent litter has increased during the past three years
- bare ground has increased slightly

None of the vegetation trends quantified were statistically significant.

Other vegetation trends and patterns appear to be more associated with natural phenomena such as soil properties or rainfall. Other trends may be artifacts of sampling time (for example, sampling a pasture before grazing one year and after grazing the next year).

Stream channel stability and stream profiles were also monitored, using the same techniques as in the paired watershed study. Stream channel cross sectional morphology showed minor cutting of upper banks and deposition on lower banks. Ratings of channel stability did not change dramatically over the seven years of the study, and ranged from high fair to high good on most transects. Particularly good ratings were associated with above-average rainfall and resultant vegetation density on streambanks. Photodocumentation comparing stream channels before and after BMP implementation did not show significant changes. Other than seasonal variations, water quality

(including turbidity, water temperature, dissolved oxygen) did not appear to change during the course of the monitoring period.

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 (RCD). Monitoring of the Chorro Flats project included an upstream-downstream evaluation of water quality (suspended sediment and turbidity) including an even-interval and storm-event sampling regime, stream profiling, benthic macroinvertebrate analysis, and a qualitative evaluation of riparian and wetland re-establishment. The lack of accurate flow data at both the upstream and downstream sites necessary to compute sediment loads, combined with the difficulty to successfully obtain suspended sediment samples, led to the decision to discontinue event-based sampling for the Chorro Flats project.

The RCD efforts partially funded by another Clean Water Act Section 319 (h) grant to monitor the effectiveness of the sediment floodplain proved to be more successful. Results from the Chorro Flats Enhancement Project Final Report prepared for the Regional Board indicate that approximately 23% of the total load, and 85% of the bed-load, from Chorro Creek between 1992 and 1998 was captured on Chorro Flats. The current estimate for sediment load from the watershed is more than twice the estimate used in 1993. Based on the annual sediment load, and the 23% trapping efficiency, it is expected that the Chorro Flats site will fill in 26 years.

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 subwatersheds 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.

Water quality sampling occurred on a weekly basis in the winter and biweekly basis in the summer. Weekly sampling for a 20-week period begins late in the fall, when precipitation increases stream flow at sampling sites. When the 20-week sampling period was not in effect, water quality sampling occurred every other week. Rapid Bioassessment was also conducted.

Elevated percent saturation, exceeding values indicative of supersaturated conditions were found at numerous sites. Additionally, elevated nitrate (NO_3^--N) and phosphate (PO_4^--P) concentrations were found throughout the watershed. Elevated fecal coliform concentrations were also found. Elevated turbidity levels were found, particularly during the high winter flow periods following the Highway-41 Fire. Mean concentrations, however, were typically low throughout the watershed. Index of Biological Integrity

scores were evaluated throughout the watershed, and the least disturbed sites received higher scores than the more impacted sites.

The Friends of the Estuary at Morro Bay, working in conjunction with the Morro Bay National Estuary Program have received a Clean Water Act Section 319 grant to continue monitoring through the Morro Bay Volunteer Monitoring Program. The volunteer monitors have assisted in collecting water quality and habitat data at the NMP sites throughout the project duration, and will continue monitoring NMP sites now that the NMP project has been completed.

The Morro Bay National Estuary Program have used the results of these studies and other efforts as a foundation to characterize the Morro Bay watershed, and to prioritize actions in a grass-roots Comprehensive Conservation and Management Plan. NMP data has also been used to develop TMDLs (Total Maximum Daily Loads) for the Morro Bay watershed.