FINAL REPORT FOR THE

ARROYO BURRO AND MISSION CREEK DRY WEATHER DIVERSION AND BACTERIAL REDUCTION PROJECT

PHASE 1: ARROYO BURRO AND MISSION CREEK BACTERIAL REDUCTION STUDY

PHASE 2: HOPE AVENUE AND HALEY STREET STORM DRAIN DIVERSIONS

This project received Clean Beaches Initiative funding through Proposition 13, per contract agreement Exhibit A, Task 7.1

State Water Resources Control Board
Agreement Number: 01-086-550-3

Prepared by:
City of Santa Barbara
Creeks Restoration/Water Quality Improvement Division
May 2007

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Introduction

Statement of Purpose

The purpose of this Proposition 13 Clean Beaches Initiative project is to lower the number of beach warnings for high levels of fecal indicator bacteria that are posted at East Beach and Arroyo Burro Beach in Santa Barbara. Phase 1 of the project includes a feasibility analysis for projects to reduce indicator bacteria levels Mission Creek and Arroyo Burro watersheds. Phase 2 of the project includes installation of two storm-drain-to-sanitary-sewer diversion projects.

East Beach, which Mission Creek empties onto, is located immediately east of Santa Barbara's Stearns Wharf (
Figure 1). Annually, about 500,000 people visit this beach, and it is especially popular with tourists as it fronts the ocean-view hotels in Santa Barbara. From 2001 to 2005, East Beach at Mission Creek was posted 7-20% of days during AB411 dates (April 1-October 31) with signs warning beach goers of the presence of bacterial pollution (Table 1).

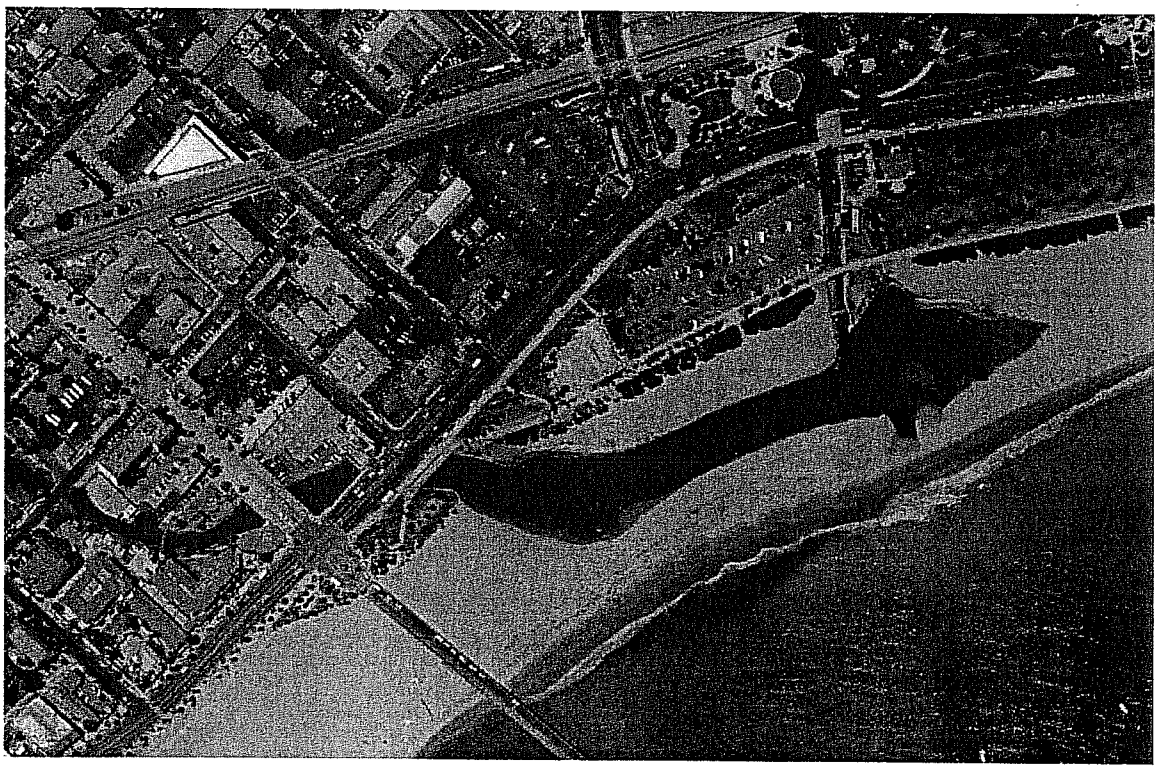


Figure 1. Mission Creek, Mission Lagoon (joined with Laguna Channel) at East Beach.

Table 1. AB411 Beach Data for East Beach at Mission Creek (April 1-October 31)

Year	Warnings	Beach Days Posted	Beach Mile Days Posted	% of Days Posted	Heal the Bay Grade (AB411 dates)
2001	6	16	0.96	7	F
2002	7	26	1.56	12	C
2003	1	2	0.12	1	A
2004	6	15	0.9	7	B
2005	13	42	2.52	20	D

Arroyo Burro Beach, of which Arroyo Burro Creek empties onto, is located approximately 3 miles west of downtown Santa Barbara and is one of the most popular beaches with residents and tourists alike (Figure 2). The beach is used for swimming, surfing, and diving. Annually, about 100,000 people visit this beach. From 2001 to 2005, Arroyo Burro Beach was posted 6-24% of days during AB411 dates (April 1-October 31) with signs warning beach goers of the presence of bacterial pollution (Table 2).

Figure 2. Arroyo Burro Estuary and creek outlet at Arroyo Burro Beach (Hendry's Beach).

Table 2. AB411 Beach Data for Arroyo Burro Beach (April 1-October 31)

Year	Warnings	Beach Days Posted	Beach Mile Days Posted	%of Days Posted	Heal the Bay Grade (AB411 dates)
2001	5	13	0.78	6	C
2002	8	25	1.5	12	C
2003	4	12	0.72	6	B
2004	7	20	1.2	9	B
2005	12	51	3.06	24	F

Recognizing the problem of water quality and its impact on human health and tourism, the City of Santa Barbara residents passed a referendum that established a 2% increase in the hotel bed tax to fund the new Creeks Restoration/Water Quality Improvement Division of the City's Parks and Recreation Department. The Division was founded in 2001 and began work in earnest trying to understand the pollution problems and to identify solutions. In the same year, the State of California established the Clean Beaches Initiative Grant Program as part of the Budget Act of 2001, Senate Bill 739 to provide funding in a statewide effort to reduce the health risks and increase the public's access to clean beaches. In accordance with the Costa-Machado Water Act of 2000, funding was appropriated for this project at East Beach and Arroyo Burro Beach.

For East Beach and Arroyo Burro Beach, the need to reduce the number of beach closures and postings is important. Because both Arroyo Burro and Mission Creek are relatively "natural" creeks running through the foothills and urban corridor of Santa Barbara before reaching their estuaries and beach outlets, neither is suitable at this time for "end-of-pipe" diversion or discharge. Therefore, the City sought funding to first study Arroyo Burro and Mission Creek watersheds to identify where polluted runoff enters the creeks and where to install appropriate water quality improvement projects. Upon completion of the feasibility study, the City sought additional funding to complete the installation of two dry weather storm-drain-to-sewer diversions. The completion of this project will help improve the overall water quality at East and Arroyo Burro beaches in the City of Santa Barbara.

Scope of Project

This scope of this project included two phases, feasibility analysis and implementation. The scope of work for phase 1 of the project was to conduct a feasibility study which mapped bacterial pollution hot spots, storm water drainage

sub-areas, major land uses, and sewer lines and their proximity to storm drains in each watershed (i.e. Mission Creek and Arroyo Burro). This information was used for preliminary assessment of dry weather diversion to sanitary sewer as well as applicable pre-treatment methods (i.e. in-line filtration and interceptor units) and on-site treatment through detention or retention of runoff and constructed wetlands. The study included a strategic plan for installing applicable Best Management Practices (BMPs) throughout each watershed as well as a prioritized list of projects for implementation in phase 2 of the project. Concept plans for up to five treatment projects were also required under the contract. The contract was amended to encumber the remaining balance of the grant monies for design and construction once the City completed the Phase 1 feasibility study, "Stormwater Treatment Options for Reducing Bacteria in Arroyo Burro and Mission Creek Watersheds."

The purpose of Phase 2 of the contract was to design and construct two storm drain diversions to sanitary sewer projects. The projects are the Haley Street Drain Dry Weather Flow Diversion to Sewer project and the Hope Drain Dry Weather Flow Diversion to Sewer project. These two projects were selected based on the results of the Phase 1 feasibility study.

Approach and Techniques

Phase 1: Bacterial Reduction Feasibility Study for Arroyo Burro and Mission Creek Watersheds

The approach of Phase 1 was to hire a consultant (URS Corporation) with expertise in water quality, watersheds, infrastructure, and GIS, to create a report that would analyze the Arroyo Burro and Mission Creek watersheds to come up with an implementation plan with the most "bang for the buck" in reducing levels of indicator bacteria. The feasibility study includes the following techniques for watershed analysis:

1. Mapping of bacterial "Hotspots" based on available water quality data from Mission Creek and Arroyo Burro from the County and City of Santa Barbara.
2. Assessment of drainage units, including stormwater drainage sub-areas and associated storm drain system based on City topographic and utility maps.
3. Mapping land uses in each drainage sub-area based on recent color aerial photography provided by the City.
4. Mapping and evaluating sewer lines and their proximity to storm drains in each watershed using the City's automated GIS map system and database. The report also indicates elevation differences at major confluences with the storm drains and sewer lines in order to identify opportunities for low flow diversions to the sanitary sewer.
5. Identification of BMPs. The report develops a list of feasible, effective, and applicable BMPs for addressing bacterial pollution in the watersheds.

6. Assessment of low flow diversion options.
7. Assessment of satellite treatment facilities, including types of treatments, size of facilities, effectiveness of pollutant removal, and costs.

Using data from this analysis, the study developed a strategic plan for installing pre-treatment and treatment BMPs, including rationale for type, location, and priority ranking of BMPs. The study also identifies early action diversion projects that could be implemented immediately.

Phase 2: Design and Construct the Hope Avenue and Haley Street Dry Weather Storm Drain to Sanitary Sewer Diversion Projects

The approach for Phase 2 was to hire a consultant to prepare final design plans and specifications for the Hope Avenue and Haley Street Dry Weather Storm Drain Diversion Project. The two dry weather diversions were identified as being high priority due to the severity of pollution and feasibility of installation in the Phase 1 study. The scope of work for Phase 2 included:

1. Development of detailed construction plans and specifications.
2. Construction of the project.
    a. Advertisement of the construction contract for bids in accordance with Public Contracting Code.
    b. Construction of the project in accordance with final plans and specifications and document completed project with evidence in the form of photos and Notice of Completion.
    c. Start the system and monitor the system operation, instrumentation, pump, and other equipment to ensure that all equipment are functioning according to design.

Task Deliverables Submitted Previously

The tasks deliverables submitted previously include are shown in Table 3.

Table 3. Deliverables and Completion Dates

Deliverable	Completion Date
Project Management and Administration	April 2003 - May 2007
CEQA Monitoring and Budget	December 2005 to Completion
QAPP and Monitoring Plan	September 2006
Bacterial Reduction Feasibility Study for Arroyo Burro and Mission Creek Watersheds	March 2006
Project Final Design	September 2005
Construction	March 2007

Project Results

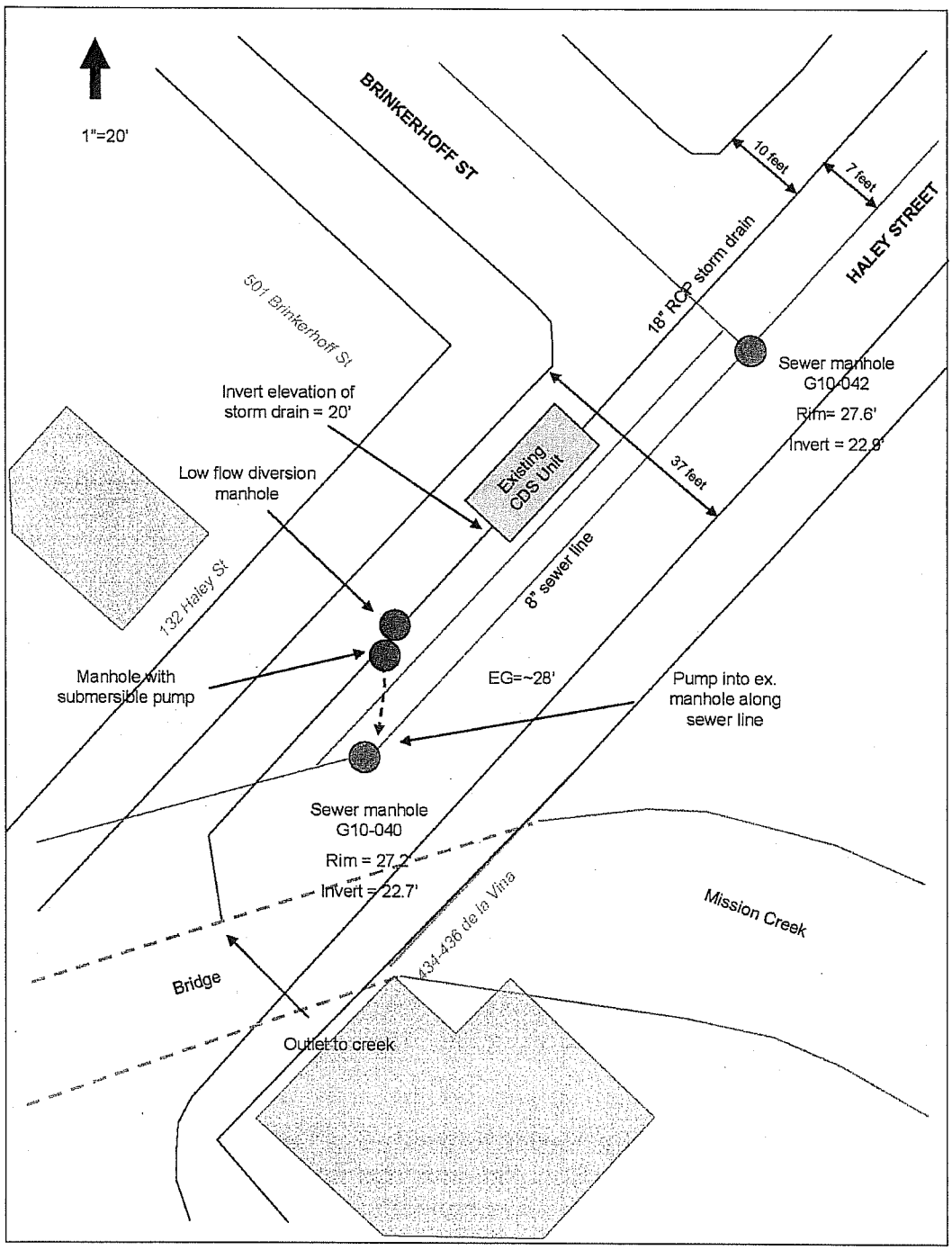
Phase 1:

The Phase 1 feasibility study, "Stormwater Treatment Options for Reducing Bacteria in Arroyo Burro and Mission Creek Watersheds" was completed successfully and has been highly instrumental in providing direction for the City's capital program to reduce beach warnings. The report includes concept designs for the Hope Avenue and Haley Street Diversions, as shown in Figure 3 and Figure 4. In addition to GIS files and data analysis for each of the items listed above, the report also includes concept designs for an ultraviolet disinfection facility at the Westside Drain into Old Mission Creek. Design and construction of the project, referred to as the Westside Summer Urban Runoff Facility (SURF), has been completed with grant funds from the Proposition 40 Clean Beaches Initiative program.

The feasibility study, informally called the "Bacterial Reduction Study," has been used to inform Phase 2 of the project in the following ways:

- Mapping of bacterial hotspots, particularly at drain outlets, aided prioritization of project locations.
- Maps of drainage subareas helped in modeling runoff patterns, which was used in sizing pipes, pump stations, and channels for the diversions.
- Maps of land use assist in making qualitative predictions about the types and quantities of pollutants, which was used when discussing potential impacts of the diversions on the wastewater treatment plant.
- Systematic evaluation of proximity of storm drains to sanitary sewers helped in ranking the diversion options and helped early in the design process for estimating construction costs.

The role of a watershed study, including quantitative assessments of drain areas, pollution levels, and cost-related elements, is vital for strategic planning and achieving reductions in pathogen and/or indicator bacteria levels. In fact, the Bacterial Reduction Study has been used to provide an enormous jump start on microbial source tracking research. The study has also been used to guide the City's move to require of installation of BMPs in development projects.



Storm Drain Diversion – Haley Street

Figure 3. Haley Street Diversion concept drawing.

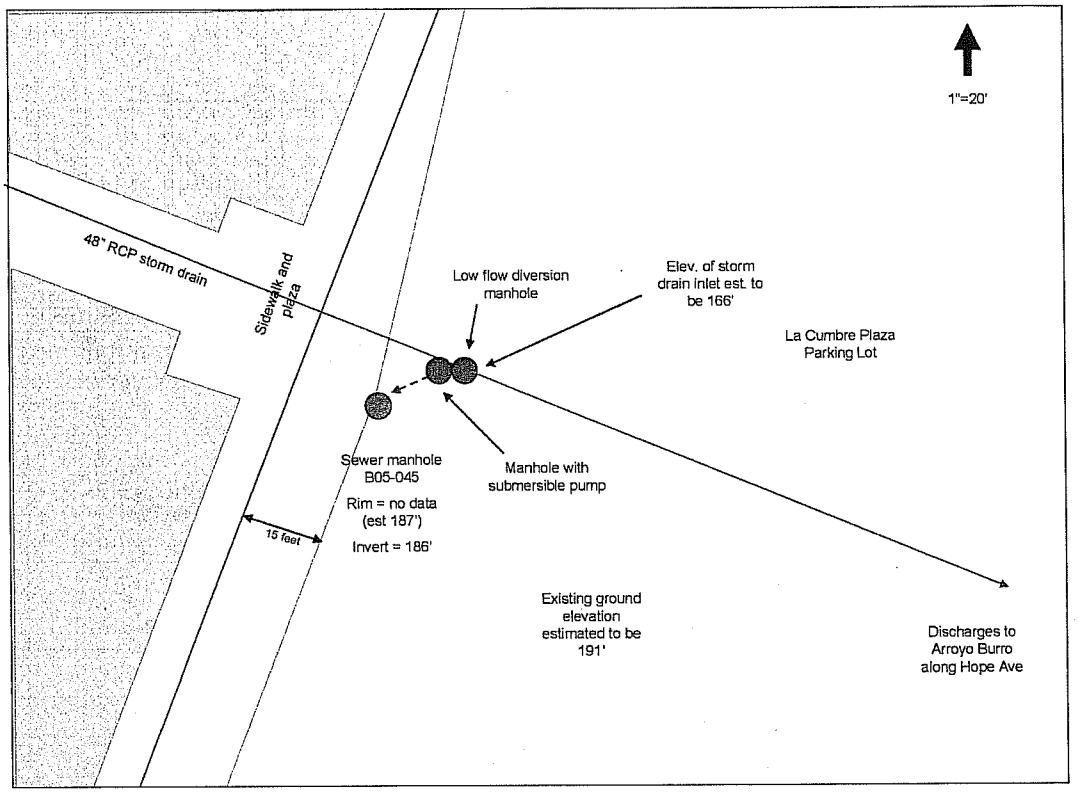


Figure 4. Hope Avenue Diversion concept drawing.

Phase 2:

The Hope Avenue and Haley Street storm drain diversions were designed and installed successfully. Project design was carried out by URS Corporation, along with input from the City's Engineering Services Division of the Public Works Department and projection coordination by the City's Creeks Division. The project was constructed by Tierra, with construction management services provided by URS and the City's Engineering Services Division. The Haley Diversion began operation on July 22, 2006. The Hope Avenue Diversion was completed on March 15, 2007.

The Haley Street Diversion was designed and built as laid out in the concept plan. A diversion manhole was installed downstream of the existing solids removal device (CDS unit). A low-flow channel at the base of the manhole diverts flow to a second manhole, housing a pair of submersible pumps. The flow is then pumped to near grade, passes through a valve manhole, and then enters the existing sanitary sewer line for treatment at the City's El Estero Wastewater Treatment Plant. Design and construction of the Haley Street diversion was complicated by the discovery underground utilities that were not on

utility maps and by the movement of underground utilities due to a future bridge replacement. There were no other major obstacles to construction.

The Haley Street Diversion is designed to pump 150 gallons per minute (gpm) when one pump runs and 300 gpm if both pumps run together. Usually the flow in the drain is far below 150 gpm and the pumps alternate acting as "lead" and "lag." As will be disused below in the Load Reduction section, the pumps are set to move 423 gallons each time they begin operation. Given a typical flow of 10 gpm in the storm drain, each pump cycles approximately once per hour. The pump controls and history can be accessed remotely. The record of pump activity is discussed below in Load Reduction.

The Hope Avenue Diversion design was altered significantly from the concept plan and encountered more obstacles during design and construction. The concept plan shows a similar layout to the Haley Diversion, in that a pump station would be used to move flow in the storm drain up to the level of the sanitary sewer line. Upon completion of the 90% plans, it was learned that two printed sources of utility information were contradictory, and that the storm drain might be of higher elevation than the sanitary sewer line. After survey work and field reconnaissance, it became clear that a pump station would not be necessary and that gravity could feed the storm drain flow to the sanitary sewer, requiring a change in design.

In addition, right of way issues complicated design of the Hope Avenue Diversion. In contrast to the Haley Street Diversion, which is located on a pubic right of way (street), the Hope Avenue Diversion is located in the privately owned parking lot of a shopping mall. Utility easements for the storm drain and sewer line provided the legal right to install the project. However, the narrow space of the easements made fitting the gravity system in quite challenging. Upon construction of the project, it was discovered that the system did not provide sufficient head pressure to divert the flow. A removable weir was installed in order to increase head pressure and push the storm drain flow through the diversion channel. In addition, during construction, the discovery of unmarked utilities created several delays.

Maintenance

The Haley Street Diversion has required little maintenance since the beginning of operation. The pumps have functioned without alarms and there has been no clogging, likely due to the upstream solids removal device (continuous deflective separation, or CDS) and masticating pumps. The pump operation is checked weekly. The facility pumps approximately 17,000 gallons per day (Figure 5).

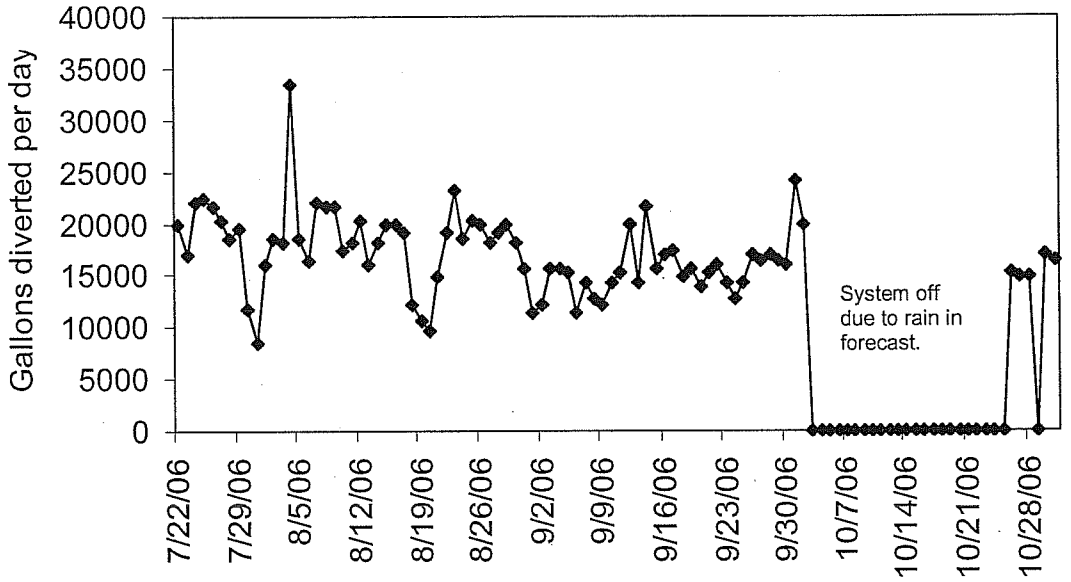


Figure 5. Gallons pumped per day at the Haley Street Diverson.

The City's El Estero Wastewater Treatment Plant, which receives the diverted runoff from the project, is not capable of receiving additional runoff during storm events. Therefore, the diversions are turned off when rain is forecast during the week or on weekends. During the month of October, rain was forecast nearly every week and the Haley Street Diversion was off-line much of the month, accordingly.

Due to the need to design and install a removable weir, the Hope Avenue Diversion was only recently completed, well past the end of the 2006 AB411 season. The low flow diversion channel and grate are checked weekly and do require frequent cleaning. Because of the depth of the diversion manhole, cleaning requires Confined Space Entry and is a substantial operation. The Creeks Division will investigate the installation of screens on the drop inlets in the drainage area to ameliorate this problem.

Water Quality Monitoring

The Creeks Division has a comprehensive water quality monitoring program and has incorporated monitoring for the diversion projects into the overall program. The goals of the monitoring plan are to:

1. Quantify the loads of indicator bacteria that are prevented from entering Arroyo Burro and Mission Creeks as a result of installing the Project.
2. Quantify the effect of the Project in reducing loads of indicator bacteria entering Arroyo Burro and Mission Creek, i.e. quantify the fraction of runoff that is diverted for treatment.

3. Test for the effect of eliminating or reducing the input of microbial contamination on concentrations of indicator bacteria in downstream creek reaches.
4. Test for the effect of the Project on reducing beach postings. Data on beach postings will be obtained from the Santa Barbara County.

Sampling was carried out according to the approved QAPP and Monitoring Plan, with the following exceptions:

1. Sampling for the Hope site was not conducted during the AB411 season because the project was not completed.
2. Sampling frequency at the Haley site was reduced from weekly to monthly due to the staff resources required to control traffic and sample safely.
3. The median value for indicator bacteria measurements was used to calculate load estimates.

Water Quality Results: Load Reduction

The load of indicator bacteria prevented from entering Mission Creek during the 2006 AB411 season was approximately 1.24×10^{12} total coliform bacteria, 1.82×10^{11} *E. coli* bacteria, and 1.26×10^{11} enterococcus bacteria (Figure 6, Figure 7, and Figure 8). The loads were calculated based on the daily flow volumes multiplied by the median indicator bacteria values during the season. The daily flow volumes were determined by multiplying the pump starts per day times the volume pumped per start. The volume per start is based on the geometry of the pump station and the heights at which the pumps turn on and off:

$$\text{Volume per start} = (\text{pump level}_{on} - \text{pump level}_{off})\ \pi\ r^2\ (7.5 \text{ gallons per ft}^3)$$
$$= 423 \text{ gallons per start}$$

Where pump level_{on} = 16.0 ft
pump level_{orr} = 14.0 ft
r = 3 ft

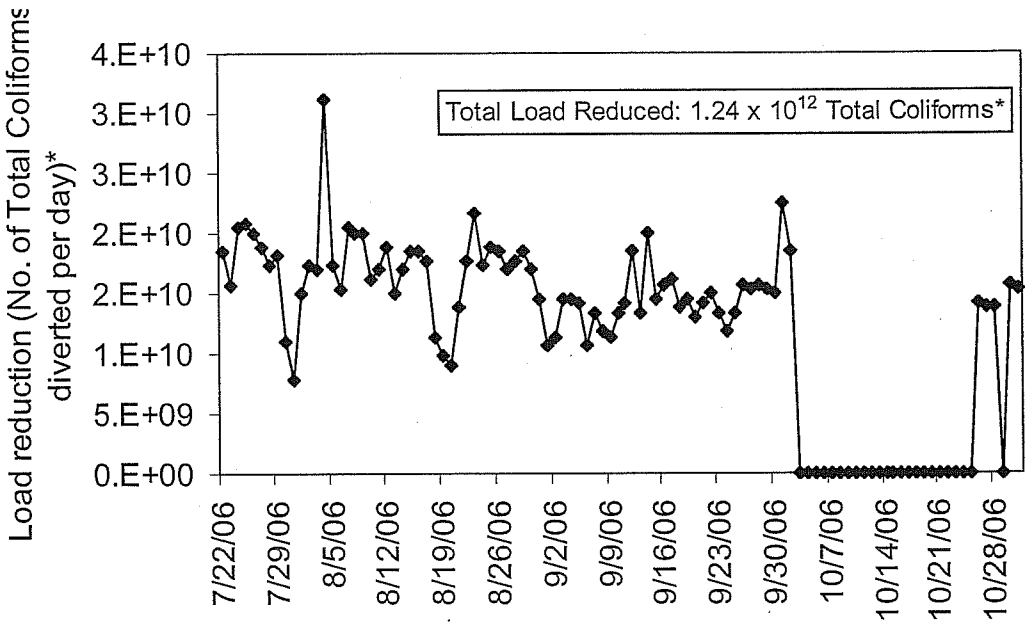


Figure 6. Load reduction of total coliforms during the 2006 AB411 season as a result of the Haley Street Diversion. Please note that this is a conservative estimate because many of the total coliform measurements used in the calculations were greater than a threshold value, but the threshold value was used for calculations.

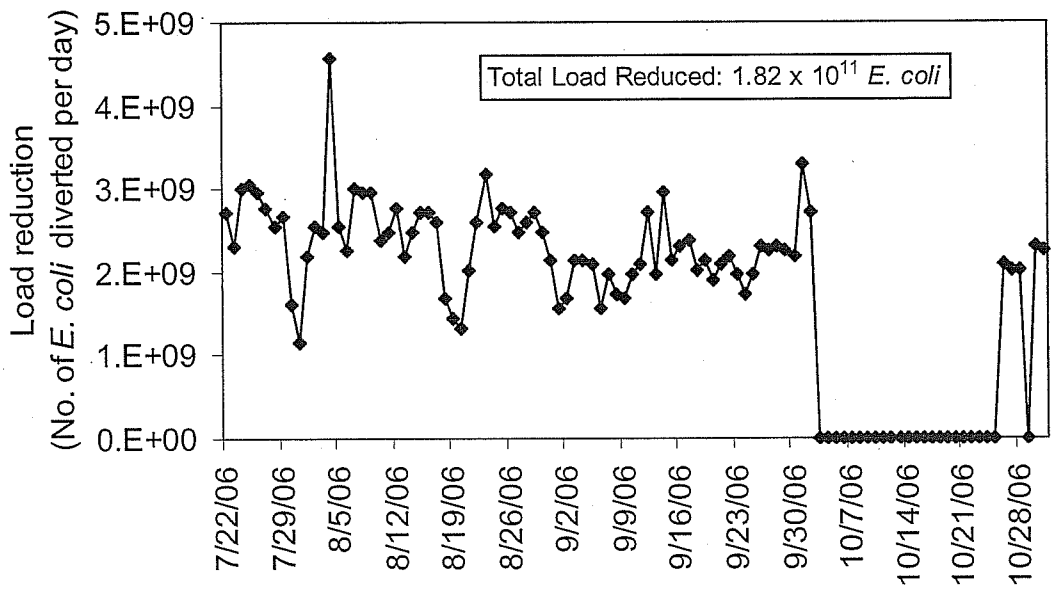


Figure 7. Load reduction of *E. coli* during the 2006 AB411 season as a result of the Haley Street Diversion.

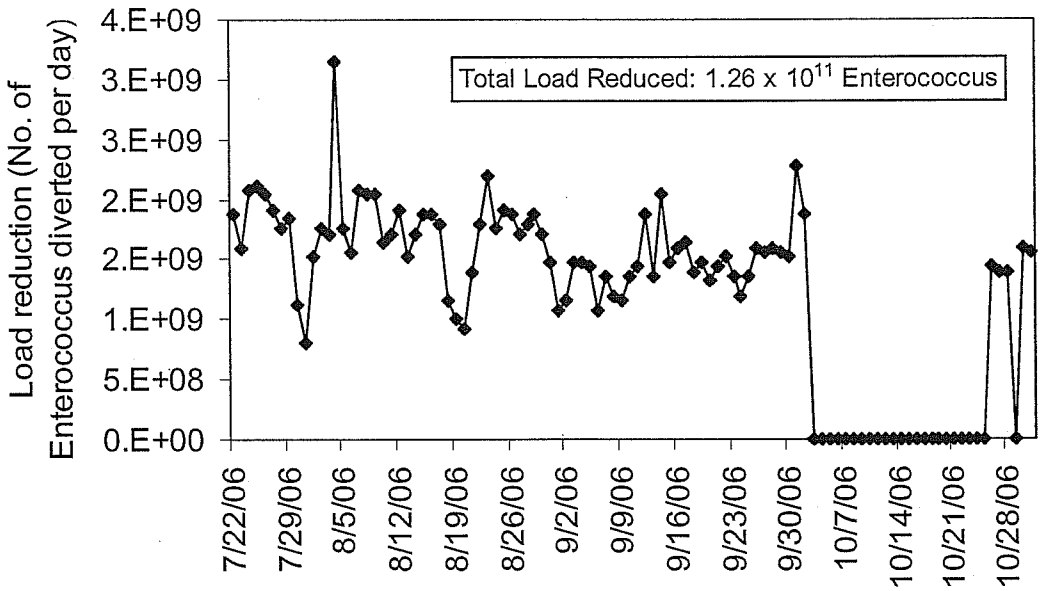


Figure 8. Load reduction of enterococcus during the 2006 AB411 season as a result of the Haley Street Diversion.

The proportion of flow treated on a daily basis was not determined because the Haley Drain was not observed to be flowing on sampling days.

Water Quality Results: Downstream Impacts

The downstream impact of the diversion projects is of chief interest to the Creeks Division and the local community. Surprisingly, the concentration of indicator bacteria in the creek downstream of the project did not change noticeably as a result of project installation (Figure 9). It is important to note however, that whether or not the project impacts downstream indicator bacteria concentrations that the creek and ocean certainly have fewer pathogens than prior to project installation. The importance of the diversions in keeping water safe for swimming is highlighted by results from the City's research with Dr. Patricia Holden, which has identified the consistent presence of human waste at the Hope Avenue and Haley Street storm drains, as discussed below in Additional Benefits.

This result also points to the importance of expanding the focus of the State's efforts to research and development of additional assessment and source tracking tools, as described in the Proposition 50 Clean Beaches Initiative grant guidelines.

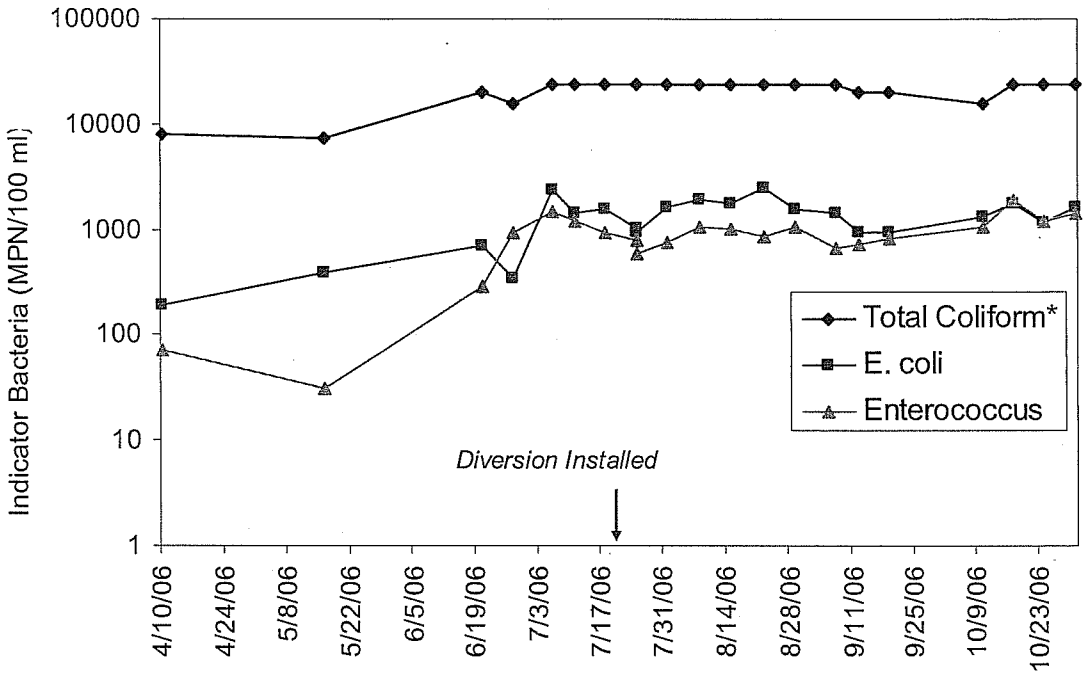


Figure 9. Indicator bacteria concentrations at Mission Creek downstream of the Haley Street Diversion site.

Water Quality Results: AB411 Beach Data

Overall, beach water quality in California was better in 2006 than in 2005 due to a relatively mild winter. At Arroyo Burro Beach, sporadic exceedances of AB 411 standards for indicator bacteria occurred throughout the summer (Figure 10). Similarly, East Beach at Mission Creek had beach warnings for each indicator (Figure 11). The AB411 indicator bacteria data collected by the County in the surf zone did not reflect the installation of the Haley Street Storm Drain Diversion, which began operation on July 22, 2006. As stated above, it is very important to note that these results do not mean that the ocean is not safer for swimming and recreation.

As mentioned in the Introduction, Arroyo Burro and Mission Creek are not suitable for end-of-pipe treatment near the beach. Because of this limitation, the City has long known that decreasing the number of beach warnings will require a long-term capital strategy that includes installation of diversion and treatment projects at multiple drain outlets, augmented by source reduction achieved by education, outreach, and enforcement activities. Despite the lack of results in indicator bacteria levels and beach warnings, the City and residents are encouraged that the number of pathogens in the creeks, and ultimately the oceans, has been decreased by the installation and operation of the dry weather diversions.

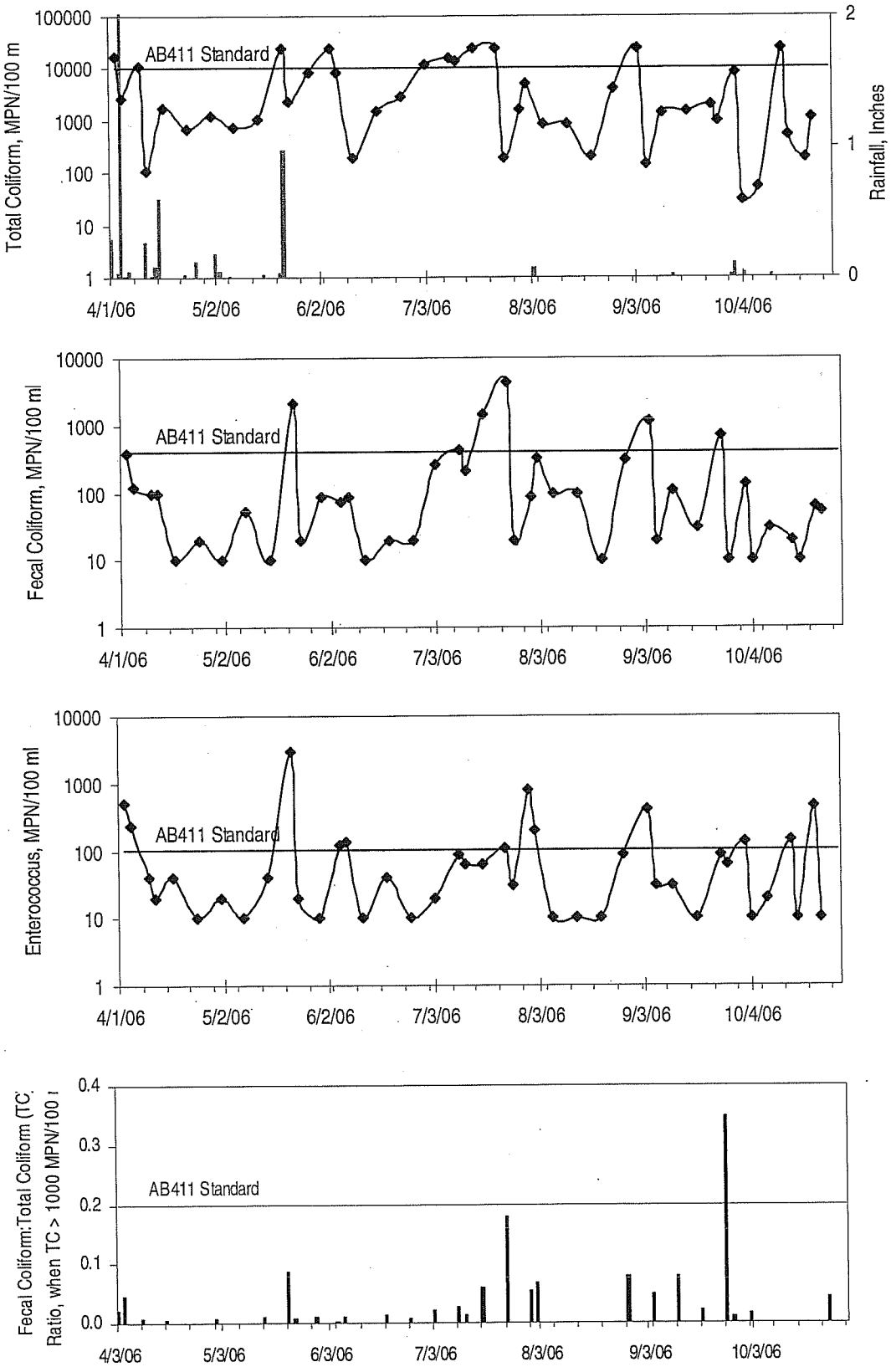


Figure 10. 2006 AB 411 data from Arroyo Burro Beach.

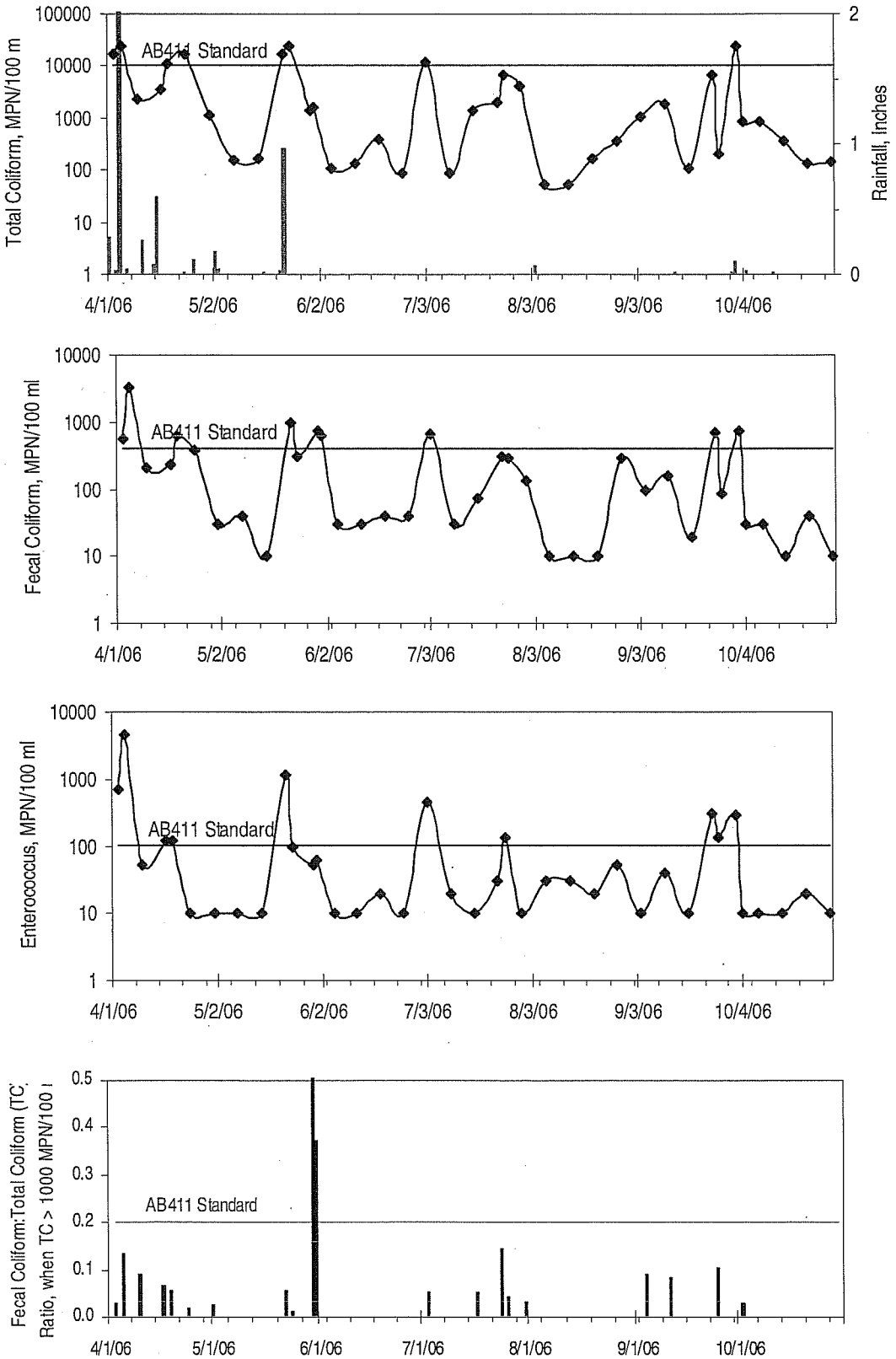


Figure 11. 2006 AB411 beach data for East Beach at Mission Creek.

Additional Benefits

Microbial Source Tracking Research

In addition to indicator bacteria testing, the City has conducted additional research that demonstrates the importance of the diversions in reducing health risks from recreational contact. Due to the many limitations with indicator bacteria data, the City has worked with Dr. Holden at UCSB in order to develop DNA-based methods that can be used to determine if human waste is present in creek, lagoon, and ocean samples. The project involved the development and application of new methodologies that can be used for discovering human waste in urban watersheds. The project also involves the identification of potential upstream and intermediate sources of contamination, and the assessment of the fates of contamination during transport in the creek, through the lagoons, and into the ocean during summer low-flow conditions. This research was not required by or described in the Monitoring Plan or the QAPP and is presented here as supporting evidence of the importance of the diversions.

A "snapshot" of lower Mission Creek was conducted to survey human waste indicators in sampled waters. These studies were replicated over 3 days (June 28-June 30, 2005) to better understand temporal variability in the signals. Results showed evidence of human fecal contamination in runoff from the Haley Street storm drain on each of the three days.

A "snapshot" of lower Arroyo Burro watershed was also conducted. This snapshot was replicated over 3 days (August 22-25, 2005). Results showed consistent contamination in runoff from Hope Avenue storm drain and transient contamination in other sites.

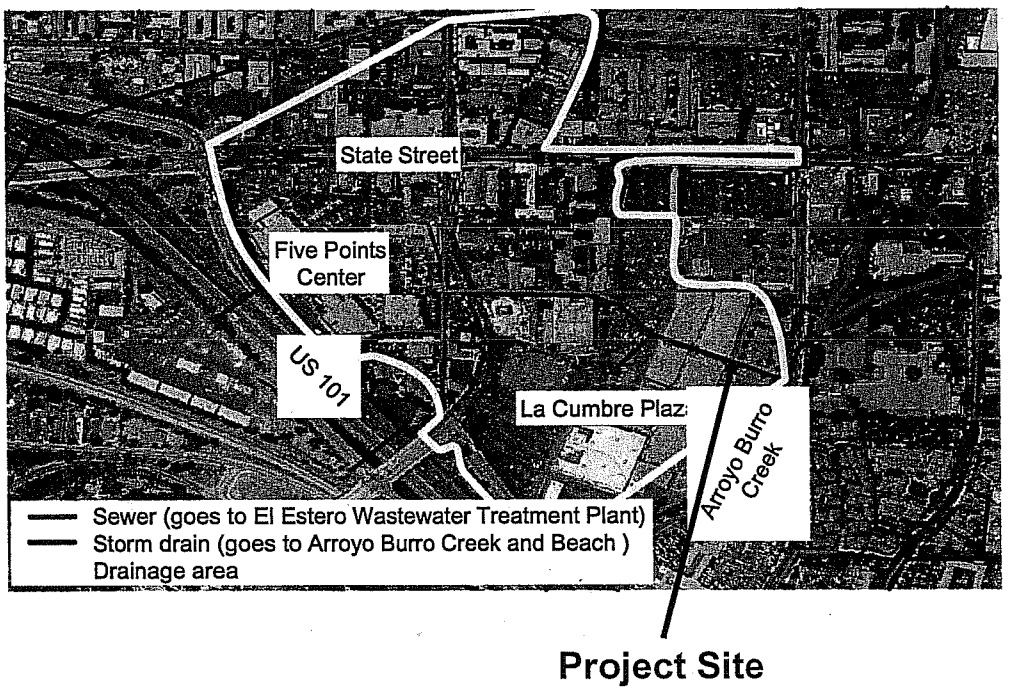
Based on the results at the Haley Street storm drain, a fate and transport study was focused on the Haley Street storm drain. Samples were collected on the first day (August 4, 2006) from two creek sites downstream of the Haley Street storm drain, the drain itself, and two manholes upstream in the storm drain. On the second day, samples were collected from the two creek sites downstream of the storm drain, the drain itself, and a creek site upstream of the storm drain. This scheme was replicated three times throughout the day. Results confirmed the presence of human waste in the Haley Street storm drain, demonstrated temporal variability in the signal, and provided data for the transport model, which is still being analyzed. Indicator bacteria values obtained from these samples were also high, which is not surprising given the direct evidence of human waste or sewage.

Outreach

An additional benefit of the project is the opportunity it presented for outreach and education of the community in the surrounding neighborhoods. When notices of construction and traffic disruption were mailed to residents, the opportunity was taken to explain the concept of drainage areas, urban runoff in storm drains, and how the diversions would improve water quality, as shown on the following pages.

Water Quality Improvement Project
Hope Avenue Storm Drain Diversion

Construction on Santa Barbara's latest creek water quality improvement project is scheduled to begin January 2, 2006. The project will divert polluted urban runoff from the Hope Avenue storm drain, which conveys runoff from commercial areas along upper State Street and discharges the flow to Arroyo Burro Creek. This location is known to have high levels of indicator bacteria, which contribute to poor creek water quality and beach warnings at Arroyo Burro Beach.



Addressing Water Quality Concerns: Did you know that much of the water used to water lawns, wash sidewalks, and spray parking lots, flows to storm drains and then to the creeks and ocean untreated? Some of this *urban runoff* is highly contaminated with microbial pollution. The City of Santa Barbara has received grant money from the State's Clean Beaches Initiative to reroute urban runoff at this site to the sanitary sewer system during the summer, with the ultimate goal of reducing beach closures.

Timeline and Staging Area: The Hope diversion is located underground in the parking lot at La Cumbre Plaza near Hope Street. The project is expected to begin on January 2, 2006 and is projected to end on January 31, 2006.

Thanks to the La Cumbre Plaza and the Macerich Company for participating in project construction.

For more information call: 897-2658
or visit www.sbcreeks.com

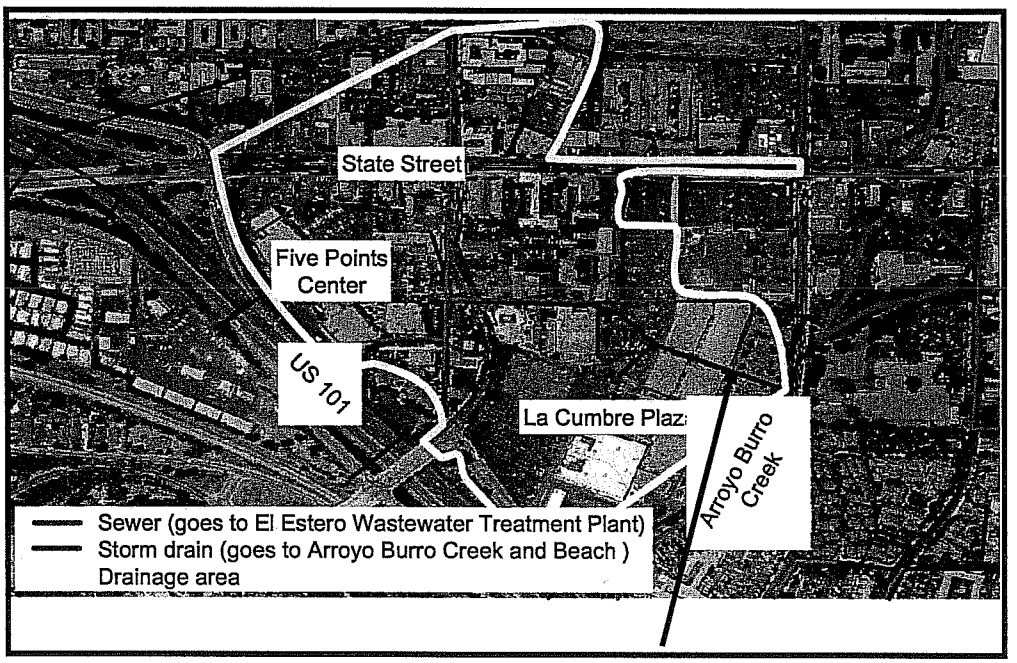
We appreciate your patience during construction.
Thanks for supporting clean creeks and healthy beaches!

Clean Creeks
HEALTHY BEACHES
CITY OF SANTA BARBARA

Funded by the Clean Beaches Initiative and Measure B

Water Quality Improvement Project
Hope Avenue Storm Drain Diversion

Construction on Santa Barbara's latest creek water quality improvement project is complete. The project diverts polluted urban runoff from the Hope Avenue storm drain, which conveys runoff from commercial areas along upper State Street and discharges the flow to Arroyo Burro Creek. This location is known to have high levels of indicator bacteria, which contribute to poor creek water quality and beach warnings at Arroyo Burro Beach. The Hope Avenue diversion is located underground in the parking lot at La Cumbre Plaza near Hope Street.



Project Site

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Clean Creeks
HEALTHY BEACHES
CITY OF SANTA BARBARA

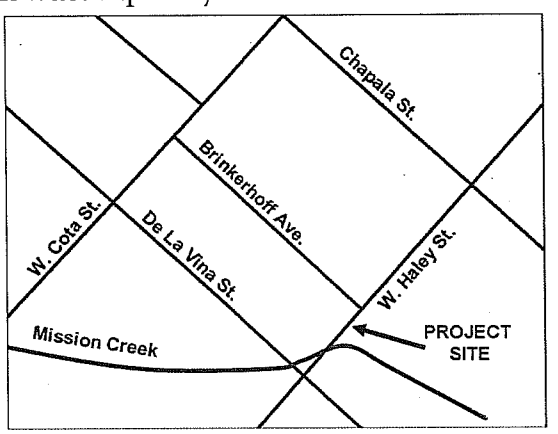
Funded by the Clean Beaches Initiative and Measure B

Water Quality Improvement Project

Haley Street Storm Drain Diversion

Location: Haley St. between De La Vina St. and Brinkerhoff Ave.

Construction on Santa Barbara's latest creek water quality improvement project has been re-scheduled for January 31-February 28, 2006. Throughout construction, the westbound traffic and parking lanes will be closed on Haley St. between Brinkerhoff Ave. and De La Vina St. The eastbound driving lane of Haley St. will be closed periodically during construction.



The project will divert polluted urban runoff from the Haley [illegible] storm drain, which conveys runoff from the downtown area and discharges to Mission Creek. The City of Santa Barbara [illegible] has received grant money from the State's Clean Beaches [illegible] to reroute runoff to the sanitary sewer system during [illegible] summer, with the ultimate goal of improving water quality and reducing beach closures.

Clean Creeks
HEALTHY BEACHES
CITY OF SANTA BARBARA

Thank you for your patience during construction!

Contact: City Creeks Division, 897-2658