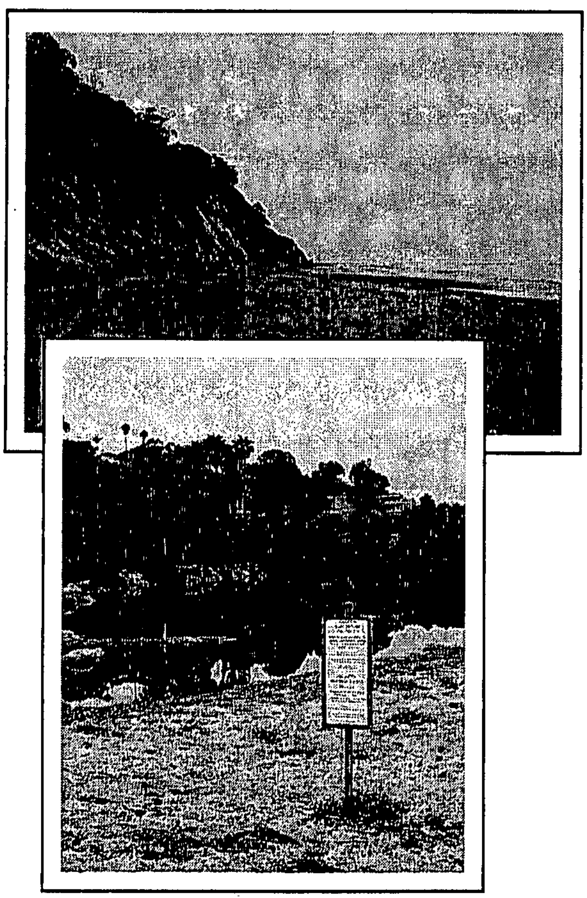
EVALUATION OF BEACH ADVISORY ZONES

An Initial Field and Literature Investigation on the Lateral Extent of Beach Advisory Zones Due to Elevated Bacteria Levels

County of Santa Barbara - Project Clean Water



August 1999

Prepared for:

Santa Barbara County
Public Health Department

Santa Barbara County
Water Agency

City of Santa Barbara
Department of Public Works

Prepared by:

URS Greiner Woodward-Clyde

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County Public Health Department: 225 Camino Del Remedio
Santa Barbara, California 93110
Contact: Mr. Dan Reid
805-681-4900

Prepared by:

URS Greiner Woodward-Clyde
130 Robin Hill Road, Suite 100
Santa Barbara, California 93117
Contact: Dr. John Gray
805-964-6010

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Since 1996, Santa Barbara County Public Health Department (County) has conducted weekly water quality sampling of sixteen local beaches. The purpose of the sampling is to identify elevated levels of coliform and enterococcus bacteria in the ocean water which indicate risk of adverse health effects such as skin rashes, sinus infections, and gastrointestinal illness. When high levels of these bacteria are detected in the surf zone, the County issues an advisory or posts beach closure signs, depending upon the bacteria concentration. The media is also provided with weekly updates on the status of beach advisories and closures. When a beach advisory is issued, the public is warned about elevated bacteria concentrations and directed to avoid contact with ocean water in front of, or adjacent to, creek mouths or storm drains. A closure is posted when bacteria levels exceed state public health standards. The County directs the public to avoid contact with the ocean water for a distance of 400 yards (1/4 mile) on either side of the creek at the beach. The beach advisory and closure signs remain in place until bacteria levels have dropped below the standards.

The primary source of coliform bacteria in the ocean water at local beaches is water in the creeks consisting of winter stormwater runoff, groundwater discharge to the creek, and runoff generated from urban and agricultural water uses. In the summer of 1998, many beaches were closed for extended periods of time due in part to the prolonged runoff in the creeks following a very wet winter. The beach advisories prompted concern by the public and local government agencies about public health effects on beach users and on the conditions of the coastal watersheds. The County of Santa Barbara, in cooperation with the cities of Santa Barbara and Carpinteria, initiated several programs in 1998 to assess the level of pollution in selected creeks, investigate sources of bacteria pollution, educate the public, and implement short and long term actions to reduce bacteria levels in the creek.

The primary program is called Project Clean Water. The key component of this program was to investigate the sources and levels of bacteria pollution in local watersheds through an extensive field investigation. Based on the results of this investigation, the County and cities have taken actions to remove obvious pollutant sources from the watersheds. In addition, Project Clean Water involves the development of long-term solutions, including (among others) best management practices for managing stormwater quality through source reduction and near-source treatment.

1.2 STUDY OBJECTIVES AND SCOPE

One element of Project Clean Water is to evaluate the beach advisory distance used by the County, and to determine if a narrower advisory zone would be appropriate based on measured bacteria levels and site-specific conditions at each beach. This evaluation was conducted as a "test case" at

Arroyo Burro Beach, a very popular beach located within the City of Santa Barbara. It was reasoned that if the study results were definitive at Arroyo Burro Beach, then the study methods and/or its results could be applied to other public beaches. The overall intent of the study was to determine if the lateral extent of beach advisories could be safely decreased in order to reduce the inconvenience to beach users during beach advisories or closures. The study was designed only to address beach advisories in the summer when beach use is high and creek runoff is very low to absent.

The specific objectives of the study were as follows:

1. Document the levels of bacteria in the upper surf zone relative to the distance from the creek mouth based on field sampling

2. Identify factors that affect the lateral extent of elevated bacteria in ocean water near creek mouths, including creek discharge, dispersal of freshwater plumes, oceanographic factors such as wave action and direction, dilution and mortality with time and distance, and other factors, based on available literature.

3. Identify standardized methods for collecting water samples and evaluation criteria that would indicate when advisories of less than 400 yards on either side of the creek mouth would be appropriate, consistent with applicable State Department of Health Services regulations on monitoring beach water quality for public health purposes.

4. To the extent feasible, develop new criteria for beach advisories at Arroyo Burro Beach for the summer of 1999.

It is important to note that this study only addresses bacteria dispersal during the summer months when the creek flows are minimal and severe wave action (typical of winter storms) are absent. In addition, this study does not address the accuracy and reliability of using bacteria as indicators of viral pathogens, the most common cause of beach-related illnesses. Use of these indicators is the commonly accepted practice that is now established in state regulations. This study is based on the use of these indicators (total coliform, fecal coliform, and enterococcus), but does not attempt to correlate elevated levels of indictors with risk of illness.

2.0 BACKGROUND INFORMATION

2.1 STATE REGULATIONS

Health and Safety Code Section 115880 authorizes the Department of Health Services (DHS) to establish sanitation standards for public beaches by adopting regulations that require the following:

- Establish protective minimum standards at public beaches for total coliform, fecal coliform, and enterococcus bacteria
- Test waters adjacent to public beaches for total coliform, fecal coliform, and enterococcus bacteria on at least a weekly basis from April 1 through October 31, inclusive, of each year, beginning in 1999, if the beach is visited by 50,000 or more people per year and is located adjacent to a storm drain that flows in the summer.
- Establish protocols for water quality monitoring and public notification of health hazards, including posting, closing, and reopening beaches.

Under the provisions of the Health and Safety Code, the local public health officer is responsible for: (1) testing ocean water in accordance with the regulations; (2) informing the agency responsible for the operation and maintenance of the public beach within 24 hours of posting; (3) establishing a telephone hotline to inform the public of all beach postings; (4) producing an annual report on beach closures; and (5) taking certain prescribed actions in the event of an untreated sewerage release. The costs of implementing these requirements are covered by the state.

Health and Safety Code Section 115915 requires that the health officer must post the beach with conspicuous warning signs to inform the public of the nature of the problem and the possibility of risk to public health. A warning sign must be visible from each legal primary beach access point.

Health and Safety Code Section 115880 was established by Assembly Bill 411 in 1997. Regulations implementing the provisions of this section of the Code were to be formally adopted by December 31, 1998. However, final regulations were not adopted until July 26, 1999. The final regulations (Title 17 of California Code of Regulations, Group 10) contain the following provisions:

- **Bacteriological Standards.** As a result of the recent state legislation (AB 411), the minimum bacteriological standards for protecting waters adjacent to public beaches or areas of public water contact sports are listed below. It should be noted that the Health and Safety Code allows counties and cities to adopt standards for the sanitation of public beaches that are stricter than the following:

1. Based on a <u>single</u> sample, the density of bacteria in water from each sampling location at a public beach shall not exceed:

   (a) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or
   (b) 10,000 total coliform bacteria per 100 milliliters; or
   (c) 400 fecal coliform bacteria per 100 milliliters; or
   (d) 104 enterococcus bacteria per 100 milliliters.

2. Based on the <u>mean</u> of the logarithms of the results of a least five weekly samples during any 30-day sampling period, the density of bacteria in water from any sampling station at a public beach or public water contact sports area, shall not exceed:

   (a) 1,000 total coliform bacteria per 100 milliliters; or
   (b) 200 fecal coliform bacteria per 100 milliliters; or
   (c) 35 enterococcus bacteria per 100 milliliters.

- **<u>Bacteriological Sampling.</u>** Water quality samples at public beaches and public water contact sports areas must be collected at such frequencies as may be determined by the local public health officer or DHS. For public beaches with more than 50,000 visitors per year and which are located adjacent to storm drains (defined in the regulations to include creeks) that flow in the summer, water sampling must occur on a weekly basis from April 1 through October 31st. Water quality samples must be taken from locations that include the areas affected by storm drains in "...ankle- to knee-deep water, approximately 4 to 24 inches below the water surface."

- **<u>Noticing.</u>** If the testing indicates that water adjacent to a public beach fails to meet the single sample standard listed in Item 1 above, the local health officer must post warning signs and use the above-described standards (Items 1 and 2) to determine the need to restrict the use of the beach, or to close all or a portion of the beach. The regulations provide specific criteria for posting advisories, but do not provide criteria on determining the need for beach closures. DHS' "*Draft Guidance for Salt Water Beaches*" contains guidelines to be considered by the local public health officer for determining the need for closure. For example, posting an advisory would typically occur when a single bacteriological standard is exceeded due to temporary sources, or when there are periodic exceedances due to known sources such as winter stormwater, seabird concentration, etc. Beach closure would occur when the health risks are considered greater than those associated with advisories such as after untreated sewage spills, or in areas where monitoring has indicated exceedances of multiple bacteriological standards, for both the single samples and the 30-day averaged samples. The regulations allow the public health officer to determine the area to be posted and/or restricted.

It should be noted that the regulations do not require testing at locations away from the storm drain to determine the lateral extent of contamination. The regulations only require that testing occur in "... locations that include areas affected by storm drains." The non-binding guidelines in "*Draft Guidance for Salt Water Beaches*" state that more frequent sampling is appropriate when samples exceed the standards in order to determine which areas should be closed and when they can be re-opened. This document also recommends that sampling occur at the same time of the day, and that sampling should occur when recreational uses are at their peak during the day.

2.2 PRACTICES BY SANTA BARBARA COUNTY

The County began monitoring bacteria levels in ocean water at public beaches in 1996, before the passage of AB 411 and the state-mandated requirement for monitoring. Hence, a well-defined and consistent sampling protocol has been implemented for over two years. This protocol is consistent with the draft regulations and is described below.

Each Monday morning, County personnel collect a single grab sample from 16 beaches in ankle deep water in the surf zone directly in front of the creek mouth. Decisions concerning the issuance of advisories or closing a beach are based on a combination of the single sample standards and the monthly samples standards (see above). All standards are based on a 100 milliliter (ml) sample and expressed as "most probable number" (mpn) of individual bacterial cells.

If the samples exceed 10,000 mpn for total coliform, a second grab sample is collected on Wednesday to confirm the results. If the confirmation sample exceeds 10,000 mpn, the beach will be closed for 400 yards on each side of the creek mouth until a subsequent Monday sample indicates that bacterial levels have dropped below the single sample standard.

Five samples are collected over a 30-day period. The logarithmic mean of the results of these samples is calculated using samples from the most recent 30-day period. The standards for fecal coliform and enterococcus are means of 200 and 35 mpn, respectively. The standard for total coliform is two or more of the five samples exceeding 1,000 mpn during the 30-day period. If one or two monthly standards are exceeded as a result of the latest sampling event, then a beach advisory is posted. If all three monthly standards are exceeded as a result of the latest sampling event, then the beaches are closed and posted as indicated above.

The County posts the results of the weekly beach sampling in the newspaper, on the Public Health Department's website, and on the beach status telephone hotline. The beach status categories are defined as follows:

- Open - *Test results indicate that levels of bacteria meet state and EPA standards*

- Advisory - *Test results indicate elevated levels of bacteria in ocean waters at this location. Beachgoers can visit and enjoy the beach, but should avoid contact with ocean water that is directly in front of, or adjacent to creek mouths or storm drains.*

- Closed - *Test results have exceeded state or EPA standards for measured bacteria. The beach at this location has been closed and posted with warning signs. Beachgoers can visit and enjoy the beach, but should avoid contact with ocean water at least 1/4 mile on each side of the creek. Contact with ocean water that contains high levels of bacteria increases one's chance of acquiring illnesses such a rashes, fever, and diarrhea.*

Beach advisory and beach closure signs are placed at the main public entrances to the beach. Beach closure signs are placed at the beach entrances, as well as at several locations along the beach within 400 yards of each side of the creek mouth. The County selected the 400 yard limit based on the results of the 1996 study on the health effects on swimmers near storm drains in the Santa Monica Bay, entitled *An Epidemiological Study of Possible Health Effects of Swimming in Santa Monica Bay,* by the Santa Monica Bay Restoration Project.

Beach advisory or closure signs are posted by Wednesday morning if the results of Monday's sampling indicate that the monthly standards have been exceeded, or by Thursday afternoon if the results from the initial single sample test and the confirmation sample indicate that the single sample standard has been exceeded.

2.3 PRACTICES BY OTHER COUNTIES

At the time this report was prepared, each coastal county is independently interpreting the draft regulations for monitoring beach bacteria levels and posting advisories pursuant to Health and Safety Code Section 115880 (established by Assembly Bill 411). Hence, there were differences in the method of monitoring bacteria levels, methods of posting or issuing advisories, and demarcating affected areas of the beach. A summary of the different practices by three other counties (Orange, Los Angeles, and Ventura counties) prior to the adoption of the AB 411 regulations on July 26, 1999 is presented in Table 1.

It is likely that the practices listed in Table 1 will remain unchanged after July 26, 1999 except that all counties must now use both the single sample and 30-day average sample standards, and that San Diego County will need to conduct sampling on a weekly, rather than on a monthly basis to comply with the final regulations.

TABLE 1
SUMMARY OF CURRENT BEACH MONITORING AND ADVISORY PRACTICES [PRIOR TO JULY 26, 1999]

County	Time and Number of Samples	Location of Sample	Posting Practices
San Diego	Monthly; use single sample standard	Directly in front of storm drain in surf zone; re-sample 50 yards from storm drain	No specific width of advisory zone
Orange County	Daily; use 30-day average standard only	Directly in front of storm drain flows before they reach the ocean; re-sample 100 feet from drain outlet	Post signs where they will be most readily seen; no specific distance or advisory zone used
Los Angeles County	Monday, with confirmation sampling on Wednesday; use single sample standard	Sample 50 yards from storm drains in ankle deep surf zone	50 yards on each side of storm drains
Ventura County	Monday or Tuesday; re-sample on Wednesday; use single sample standard	30 to 50 yards from a storm drain in ankle deep surf zone; re-sample at 50, 100, and 400 yards from source	Post signs at public access points

3.0 STUDY METHODS

The following investigations were conducted for this study:

1. Review of the 1996 study on the health effects on swimmers near storm drains in the Santa Monica Bay, entitled *An Epidemiological Study of Possible Health Effects of Swimming in Santa Monica Bay,* by the Santa Monica Bay Restoration Project.

2. Identify physical factors during the summer that could affect the dispersal of creek water plumes in the surf zone and nearshore waters under varying creek discharge, beach profile, wave action, and tidal conditions at Arroyo Burro Beach.

3. Collect and analyze ocean water samples at varying distances from either side of Arroyo Burro Creek during non-storm conditions to determine if bacteria concentration decreases with distance from the creek mouth.

Water quality samples were planned to be collected during late February and March 1999 on four different occasions at the same time that the weekly samples were collected by the County staff. However, on the first field visit on February 22, 1999, it was observed that Arroyo Burro Creek was not flowing to the ocean. Hence, no sampling was conducted and it was decided to collect the additional samples at times when the creek was flowing to the ocean. As described in Section 4.1, there is a lagoon at the mouth of the creek that is formed by a sandbar on the beach. The creek does not flow to the ocean if there are insufficient flows to break open the sandbar and empty the lagoon. Hence, the additional sampling was conducted only when the sandbar was breached and the creek was flowing to the ocean, which occurred on the following dates: February 25, March 3, March 12, March 26, and April 13, 1999.

A single grab sample was taken at ankle high water depth directly in front of the creek mouth where freshwater and ocean water are actively mixed by wave action. This location corresponds to the same location used for weekly beach sampling program. Another grab sample was taken in the creek water before it mixed with ocean water. Additional samples were taken in ankle deep water at 25-yard intervals up to 200 yards from the creek on either side of the creek, and at 300 and 400 yards from the creek. Sample locations were temporarily marked in the field with pin flags.

Samples were analyzed for total coliform, fecal coliform, and enterococcus by the County using the same laboratory methods for the weekly sampling program.

During the first two sampling events, water temperature and salinity were measured at each sample location. The salinity and temperature data did not exhibit significant differences among sample locations and were not collected during subsequent samplings.

4.0 RESULTS OF WATER QUALITY SAMPLING

4.1 CREEK AND LAGOON CONDITIONS

The watershed of Arroyo Burro Creek extends about five miles from the Santa Ynez Mountains to its outlet at Arroyo Burro Beach County Park. The drainage in the watershed consists of the mainstem of Arroyo Burro Creek, Las Positas Creek, Barger Creek, San Roque Creek, and Lauro Canyon Creek. The bed and bank of Arroyo Burro Creek downstream of Highway 101 are unlined and contain varying amounts of native and non-native riparian vegetation. Extensive riparian woodland occurs along the creek where it is parallel to Las Positas Road.

The creek forms an estuarine lagoon at the beach that extends upstream to a concrete sill under the bridge at Cliff Drive. The lagoon is dewatered when the creek mouth is open and there are low tides. Under these conditions, a narrow low flow channel about 6 to 8 feet wide extends through the lagoon and the pond below the sill is about three feet deep. High tides of 3 to 4 feet MSL can fill the lagoon and extend to the concrete sill. Under these conditions, the pond below the concrete sill is over six feet deep.

The lagoon is subject to tidal influence on most days. High tides build up a sand berm at the mouth of the lagoon that closes the lagoon, causing a build up of water in the lagoon. If the tides are of sufficient height, the lagoon is partially or fully filled with ocean water. As the tide recedes, the hydrostatic pressure in the lagoon usually causes it to open and discharge to the ocean.

The lagoon provides habitat for ducks, shorebirds, and other water associated birds such as egrets and great blue herons. Emergent wetlands are mostly absent from the lagoon due to a lack of broad flat areas with intermittent flooding. When the mouth of the lagoon is closed, the water is stagnant and often covered with algae and floating debris. The substrate of the lagoon is sandy silt with an active decomposition layer on the surface with anaerobic conditions as evidenced by sulfuric odors during low tides.

4.2 STREAMFLOWS

The nearest gauging station along Arroyo Burro Creek is located near State Street. Based on this gauge, stream flows in Arroyo Burro Creek during May through September have ranged from 0.05 to 0.33 cfs (period of record 1971-1993). No stream gage is present near Arroyo Burro Beach, but it is generally observed that flows increase downstream of State Street due to inflows from the lower watershed. Based on observations and limited flow measurements by the County Flood Control District in August 1998, the maximum flow at the beach during the summer is 0.7 cfs (or 0.45 MGD, or about 300 GPM). The flows in the summer of 1998 were unusually high due to the high rainfall amounts in the 1997-98 winter when "El Nino" conditions were present.

4.3 BACTERIA LEVELS IN THE LAGOON AND CREEK

The County Water Agency periodically sampled water along Arroyo Burro Creek during late 1998 to determine the concentrations of total coliform, fecal coliform, and enterococcus. The median and average maximum values in the lagoon and the lower creek sampling stations during the period October 1998 through February 1999 are shown in Table 2. All values exceeded the single sample bacteria standards, except for the median enterococcus level in the lagoon, which was less than 10.

TABLE 2
BACTERIA LEVELS IN THE LOWER CREEK AND LAGOON*

Bacteria Type	Concentrations (No. per 100 milliliter)	
	Lagoon	Lower Creek (below Modoc Road)
Total Coliform		
Maximum	350,000	30,000
Median	11,500	11,000
Fecal Coliform		
Maximum	1,100	9,000
Median	800	400
Enterococcus		
Maximum	900	9,000
Median	< 10	900

*Values are approximate. Source: Project Clean Water staff report to the Board of Supervisors, 2/2/99.

4.4 BACTERIA LEVELS IN OCEAN WATER

A summary of the time, tide conditions, and creek discharge during the sampling is presented in Table 3. All sampling was conducted within two hours of the daily low tide in order to ensure that the lagoon was open and creek water was flowing to the ocean.

TABLE 3
TIDES AND CREEK DISCHARGES DURING SAMPLING

Sampling Date	Time	Tide Height (feet, MLLW)	Estimated Creek Discharge (cfs)
February 25, 1999	10:30 AM	-1.0	15
March 3, 1999	3:00 PM	+0.5	4
March 12, 1999	12:30 PM	+0.2	2
March 26, 1999	2:30 PM	+0.5	28
April 13, 1999	3:30 PM	-0.3	3.5

The bacteria levels measured at varying distances from the creek mouth during the five sampling events are shown on Figures 1 through 3. Figures 1a, 2a, and 3a show the levels of bacteria using *different scales* that are appropriate to show trends in bacteria concentration related to distance from the creek outlet. While the use of different scales for each sampling date highlights the changes in concentration with distance, it obscures the fact that the actual concentrations on different dates may vary by several orders of magnitude. Hence, the *same scale* is used on Figures 1b, 2b, and 3b to show the variability from sampling date to sampling date.

The data on Figures 1 through 3 indicate the following:

1. The highest bacteria level measured during each sampling event was generally at the creek mouth (see Figures 1a, 2a, and 3a). The only significant exception to this trend was the elevated enterococcus concentration measured 200 yards east of the creek mouth on April 13, 1999 (see Figure 3a).

2. Bacteria levels decreased with distance from the creek mouth. Bacterial indicators were present at 300 yards and at 400 yards on all occasions, but the concentrations were amongst the lowest observed and usually appeared to reflect background levels, with the exception of bacteria levels east of the creek mouth on March 26, 1999 when the creek flows were very high. See Figures 1a, 2a, and 3a.

3. There is a tendency for higher concentrations east of the creek mouth, a dispersal trend that is consistent with the prevailing longshore currents at the site. See Figures 1a, 2a, and 3a.

4. The levels of bacterial indicators varied greatly amongst the sampling dates, indicating a high variability in the bacterial input from the creek and lagoon. For example, the peak concentration of total coliform on February 25th and March 3rd was less than 300 mpn, while the peak on the following two sampling dates exceeded 24,000 mpn. See Figures 1b, 2b, and 3b.

5. There is a general correlation amongst the concentrations of total coliform, fecal coliform, and enterococcus. For example, the peak concentrations of these indicators during the study occurred on March 26, 1999, and the second highest concentrations for all three indicators occur on March 12, 1999. See Figures 1b, 2b, and 3b.

6. There was a weak correlation between the creek discharge volume and the bacteria level. For example, the highest concentrations of bacteria and the greatest dispersal of bacteria occurred on March 26, 1999 when the discharge from Arroyo Burro Creek was the highest during these study. However, there were contradictory results. The concentrations of bacteria on March 12, 1999 when the creek discharge was two cfs were significantly higher than on February 25,1 1999 when the creek discharge was 15 cfs. See Figures 1b and 2b.

7. The bacteria concentrations exceeded the state single sample standards on several occasions during the study. The total coliform levels exceeded the state standard (10,000 mpn) on two of the five sampling events. When the highest levels of total coliform were detected on March 26, 1999, there were exceedances to a distance of 75 yards (Figure 1b). Fecal coliform and enterococcus concentrations only exceeded the state standards for these indicators during one sampling event, on March 26, 1999. Exceedances for fecal coliform and for enterococcus were observed to 50 and 200 yards, respectively. The creek flows to the ocean were the highest during this sampling event on this date.

5.0 PHYSICAL FACTORS AFFECTING DISPERSAL

5.1 CREEK DISCHARGE AND LAGOON DYNAMICS

Freshwater flow in Arroyo Burro Creek is very low to absent in the summer. The discharge flow rate during summer is typically 0.3-0.5 cubic feet per second (cfs). The typical maximum flow rate was estimated to be approximately 0.7 cfs.

During the summer, the lagoon is typically closed during high tides as the waves create a sandbar that impounds runoff and seepage to the lagoon. However, during low tides, the hydrostatic pressure in the lagoon causes both seepage of freshwater to the ocean through the beach sand, and the dissipation of the sandbar allowing the lagoon to be drained. During the initial stages of dewatering the lagoon, flows may exceed 20 cfs. However, as the lagoon is lowered, the flow to the ocean is very low (e.g., less than 1-2 cfs). Hence, creek flows to the ocean in the summer are most often associated with the receding tide and low tide conditions.

5.2 WATER TEMPERATURE

Nearshore water temperature off Arroyo Burro Beach varies from a low of approximately 59 'F during winter (January-March) to a high of approximately 63-64 'F during summer and fall (July-December), based on surface-layer temperature data from available measurements along coastline from Point Conception to Santa Barbara Point (Scripps, 1981).

The temperature profiles measured in relatively deep water off Santa Barbara area (Scripps, 1981) suggest that the water column is well-mixed during winter with nearly uniform temperature from surface to bottom, while appreciable variation exists during summer. The spring and fall profiles are transitional between the two extremes. A maximum temperature stratification of 3^0F exists within the top 30 feet of surface water in the water column offshore during summer. This surface-water temperature stratification, however, is expected to decrease substantially nearshore in shallow water as wave/current/wind-induced turbulence increases, significantly enhancing the vertical mixing of water.

5.3 TIDE HEIGHTS

Water levels at Arroyo Burro Beach are results of combined effects of astronomical tides and weather conditions of different scales. Table 4 summarizes water levels based on historical data for Santa Barbara.

TABLE 4
TIDE HEIGHTS AT SANTA BARBARA

Water Level (ft)	Elevation (ft, MLLW)
Extreme High Water (Jan 1983)	8.0
Mean Higher High Water (MHHW)	5.4
Mean High Water (MHW)	4.6
Mean Tide Level (MTL)	2.8
Mean Low Water (MLW)	1.0
Mean Lower Low Water (MLLW)	0.0
Extreme Low Water (Dec 1933)	-2.6

Water levels significantly higher than MHHW are often associated with storm systems and/or El Nino conditions co-occurring with high tides. Occurrence of exceedingly high water level during storm conditions could allow large storm waves to propagate and break further inshore. However, such conditions are generally rare during the spring and summer.

5.4 WAVE CONDITIONS

5.4.1 Deepwater Wave Conditions

Storm waves generated in deep water offshore that eventually affect Santa Barbara Channel can be categorized into three primary groups by origin:

- A Northern Hemisphere swell generated by the North Pacific extra-tropical storms occurs primarily during the winter months of November through April. These waves typically approach Southern California coast from the northwest to west direction, although events with southerly approaches have also been recorded. Extra-tropical storm waves represent the most significant component of deepwater storm wave climate offshore of Southern California.

- Steep, short-period seas generated by local storm winds typically approach the Southern California coast from the west. Prefrontal winds associated with large offshore storms can also generate large seas from the southeast.

- A Southern Hemisphere tropical storm swell approaches the Southern California coast from the south. Most Southern Hemisphere swells arrive during the summer months of May through October. Because of the great decay distances, these waves have low heights and long periods. Typical Southern Hemisphere swells rarely exceeds four feet in height in deepwater; however, with periods ranging up to 18-21 seconds, these swells can amplify appreciably when propagating into shallow waters. Most of these swells are blocked by the Channel Islands, except west of Gaviota.

In summary, distant storm systems are capable of generating a large winter swell that eventually approaches the Santa Barbara area from the west. The prefrontal winds associated with these storms can create significant southeasterly waves in the Channel. Large swells can also be generated by Southern Hemisphere winter storms during the summer. However, these waves are typically of relatively low height. The sheltering effect of Channel Islands to the south of Santa Barbara can significantly reduce the importance of this type of swells relative to other waves.

5.4.2 Near-Shore Wave Conditions

Arroyo Beach is exposed to offshore waves from the west and the southeast. More significant waves from the west are primarily swells generated by Northern Hemisphere extra-tropical storms, while those from the southeast windows are typically prefrontal wind waves associated with winter extra-tropical cyclones and the Southern Hemisphere swell.

Wave characteristics transform as they propagate from deep to shallow water. Waves undergo primarily refraction when approaching Arroyo Burro Beach from offshore with directions gradually changing to become more normal to bottom contours, i.e., wave crests become parallel to the shoreline. Because of the relatively large width of the sloping shelf that leads to Arroyo Burro Beach with bottom contours becoming largely parallel to the shoreline, there is sufficient opportunity for the westerly waves to refract and eventually become relatively normal to the south-southwest-facing shoreline.

Prior studies indicate that the representative near-shore wave directions at nearby Santa Barbara Harbor area are about 149 and 192 degrees azimuth, respectively, for southeasterly wind waves and westerly storm swells (M&N, 1984 and 1996). For the slightly west-facing shoreline at Arroyo Burro Beach, the approach angles should change for both westerly and southeasterly storm waves. The westerly waves should experience less refraction while the southeasterly waves should undergo more refraction. As a result, the westerly waves are expected to be higher while the southeasterly waves lower than those at the Santa Barbara Harbor, which suggests that the westerly swell are more of a dominant factor in driving coastal processes at Arroyo Burro Beach.

5.4.3 Longshore Currents

Longshore currents are currents along the coastline within the surf zone generated by waves approaching the beach at an oblique angle and breaking in shallow water. The currents are the strongest generally within the core of the surf zone and diminish near the shoreline and away (offshore) from the surf zone. The intensity of longshore currents depends on the height and direction of the incoming waves that break outside the surf zone. The current strength increases with increasing wave heights and the obliqueness of the wave approach angle relative to the shoreline.

Results of field study and numerical modeling along the Santa Barbara coast (Wu et al., 1985) suggested that longshore currents in the surf zone along Santa Barbara coast are relatively strong due primarily to the relatively significant obliqueness of storm swell from the west. Mean current speeds up to 5.6 ft/sec under westerly storm swell conditions and 2.6 ft/sec under southeasterly prefrontal wave conditions were observed in the field. The directions of the currents were found to be consistent with the approaching waves. Currents generated during the approach of southeasterly waves from prefrontal winds (preceding westerly storm swell) are directed toward west, while those coinciding with westerly storm swell are directed toward the east. Longshore currents have not been specifically measured at Arroyo Burro Beach. However, they are expected to reflect the typical behaviors and magnitudes of the currents along Santa Barbara, that is, a predominantly easterly longshore current most of the year (COELAD, 1986).

5.5 ARROYO BURRO CREEK PLUME DISPERSAL

Physical mechanisms affecting the dispersal of a bacteria-laden discharge from Arroyo Burro Creek in relation to the required extent of beach closure primarily include the discharge jet formation; surf zone/nearshore mixing, and alongshore horizontal dispersion.

5.5.1 Discharge Jet Formation

A freshwater streamflow discharging into coastal waters normally forms a jet-like plume. The degree to which such a plume exhibits the shape of a distinctive jet depends primarily on its exit velocity, among other factors. Since the discharge flow from Arroyo Burro Creek is usually very weak during summer (e.g., May through September), no distinctive jet is expected to form during episodes of outflows. The weak momentum of the discharge plume is expected to diminish relatively rapidly upon exiting the creek mouth and undergoing substantial mixing in the surf zone.

One important process present at the site that further prevents the formation of a distinct discharge jet is the occasional build-up of sandbars at the mouth of the creek. The weak creek flow during summer fills in the lagoon before being carried out gradually on ebb tides. The outflow momentum is, therefore, entirely associated with the ebbing tidal water. Since an ebb-tide induced jet is highly sensitive to the bed forms in its path, the presence of sandbars at the mouth is expected to rapidly dissipate the potential ebb jet and create significant mixing around the creek mouth area. As a result, the discharged water is expected to become a diluted mass near the creek mouth.

It is also important to note that since the ebbing tides are the primary mechanism for carrying out the potentially bacteria-laden creek flow from the lagoon to the ocean, the process for the creek flow to get into the ocean is intermittent, following the process of tidal flushing. In addition, mixing of ocean and freshwater occurs when ocean water enters the lagoon during high tides, prior to the release of water from the lagoon during low tides.

5.5.2 Surf Zone/Nearshore Mixing

Mixing in surf zone or nearshore near a stream outlet is usually greater than in deeper water due to turbulence generated by the following processes: wave breaking, wave runup-rundown and swashing; wave interaction with shallow bottom topography; and wind-induced circulation.

Nearshore breaking waves and wind-induced vertical circulation are known to enhance vertical mixing in near-shore waters. It has been a standard procedure to treat wave-induced turbulence as an added mixing enhancement factor in modeling dispersion processes in coastal waters. In shallow water under the agitation of breaking waves, wind-induced circulation and longshore currents, the vertical mixing through the water column is generally rapid due to the high level of turbulence and small vertical scale of mixing (limited by the water depth). Density stratification, which can result from a plume of lighter freshwater discharging into heavier saltwater, can tend to suppress vertical mixing. However, such suppression of mixing is expected to be insignificant in or near the surf zone due to vertical turbulence from waves and winds.

Local mixing around the stream mouth can be further enhanced by circulation generated by tidal interaction with the mouth formation. The ebbing of tidal flow out of the creek mouth and tidal interaction with the sandbars at the creek mouth can generate nearshore eddies on both sides of the mouth which promote mixing of the exiting water with seawater near the mouth.

The above mixing processes provide initial dilution to the discharged bacteria-laden water from Arroyo Burro Creek. The dilution by turbulent mixing continues as the plume is transported and further dispersed alongshore by the horizontal dispersion mechanism of the longshore currents.

5.5.3 Along-Shore Horizontal Dispersion

The substantially mixed discharge plume mass from Arroyo Burro Creek is subject to advection by longshore currents once exiting into surf zone. Although the plume mass is expected to exit the mouth gradually following the tidal flushing process, a relatively conservative estimate of the distance of subsequent dispersal can be obtained by assuming a relatively instant release of the mass into the surf zone. The distance over which the mass disperses can be characterized by the sum of the advection distance of the core, L_{adv}, and the longshore dispersion length scale of the mass, L_{disp}. The horizontal distance is the distance the core of the plume mass moves with the longshore current, and can be estimated as L_{adv}, ~ UT_{surf}- where U is the longshore current speed, and T_{surf} is the duration of the surf. The dispersion length scale can be estimated by equating the longitudinal dispersivity in a shearing current, K_L ~ 0.6 Uh (Bowden, 1967; Fischer, 1979), where h is the water depth, with its ordering estimate, K_L - $L_{disp\,@}/T_{surf}$. This yields:

$$\text{dispersal distance} \sim L_{adv} + (0.6 L_{adv}\, h)^{1/2}$$

where L_{adv} - UT_{surf}. The dispersal distance thus estimated provides a measure of the typical distance from the Arroyo Burro Creek mouth over which elevated bacteria levels may exist (without accounting for bacteria die-off). For a plume mass discharged into surf zone subject to a longshore current at speed of 1 ft/sec for 30 minutes, the total dispersal distance from the mouth of Arroyo Burro Creek can be several hundred yards.

It must be noted that the above method provides only an approximate analysis of the alongshore dispersal of a discharge plume mass under moderate longshore currents (1 ft/sec). An accurate quantification would require site-specific measurements of the parameters involved in the analysis and a careful field calibration.

5.5.4 Bacteria Die-Off

Die-Off Rates

Densities of fecal bacteria discharged into the environment decrease over time. The die-off rate can be expressed as the time it takes for a given proportion of the population to die, or as the fraction of the remaining total population that dies per unit time. For example, half life ($T_{1/2}$) is the time it takes for the population to be reduced to 50 percent of its original size. Workers often report data in decimal log reduction, meaning the time it takes for 90 percent of the population to die. Die-off curves usually follow exponential decay kinetics.

The typical time for a 90 percent reduction in fecal bacteria in freshwater at ambient temperatures ranges from 2 to 20 days. Die-off rates are higher in seawater; for example, 90 percent reduction rates as short as several hours have been reported (Feacham *et al,* 1983). Enteroviruses have been observed to be reduced by 90 percent within 1-2 days in seawater (Fujioka *et al* 1980). Die-off rates reported in the literature are extremely variable due to the myriad of microorganisms tested and the range of environmental exposure conditions.

Factors Affecting Die-Off Rates

The ability of freshwater and fecal bacteria to persist in seawater depends on a multitude of factors, including physical factors (temperature, light), osmotic factors (salinity gradients), physiological adaptation, and predation. Bacteria usually survive longer at lower temperatures (Davenport *et al* 1976, Faust *et al* 1975) and at low osmotic pressure (Baross et al 1975). Rapid transition between freshwater and saltwater may result in severe osmotic stress, but many fecal bacteria, given sufficient food substances, can respond by activating osmoregulation mechanisms (e.g., synthesis of organic osmolytes) that provide for physiological adaptation (Munro *et al* 1989).

Solar radiation is a powerful bactericide, damaging bacteria in essential metabolic pathways and defense mechanisms (for example, inactivation of the catalase system that is responsible for removal of naturally occurring peroxides) (Kapuscinski and Mitchell 1981). At light intensities as experienced at the top few centimeter of the (clear) water column, 90 percent reduction in fecal coliform was observed within 30 minutes (Fujioka *et al* 1981).

Fecal bacteria are lost in the environment due to predation by protozoa, filter-feeding crustaceans, microflagellates, and plaque-forming microorganisms (Enzinger and Cooper 1976, Rhodes and Kator 1988, and others).

Role of Arroyo Burro Lagoon

The Arroyo Burro Creek lagoon acts as a detention basin for creek water during the summer. Based on visual observations, it is speculated that there is a residence times of several hours to a day or more in the lagoon. The net effect of lagoon environment on fecal coliform survival is a balance of several processes. Because the water in the lagoon is saline, the die-off of bacteria due to salt exposure begins in the lagoon before the bacteria is discharged to the ocean. In addition, the predation rates in the lagoon may be higher than in the surf zone, given the richer environment that can support more predatory organisms. In contrast, bacteria densities may increase in the lagoon due to fecal input by waterfowl. In addition, the lagoon sediment is a sink and a source of bacteria - it stabilizes bacterial population in the water column above it, and die-off rates in the sediment itself are much lower than in water (Gerba and McLeod 1976). At times, the lagoon provides for high-temperature and food availability conditions that may encourage actual growth (Hood and Ness 1982). The actual net effect of the Arroyo Burro Creek lagoon on bacteria levels in the ocean is unknown at this time.

Based on the above information, it is important to take into account bacteria die-off when estimating the dispersal distance of bacteria along the beach for purposes of determining the width of a beach advisory zone. Establishing the lateral extent of the beach advisory zone without accounting for bacteria die-off is likely to provide a conservative level of protection.

5.6 SUMMARY

Physical factors affecting the coastal dispersal of discharge plumes from Arroyo Burro Creek were reviewed and analyzed based on existing data. Results are summarized in the following list.

1. The summer discharge of Arroyo Burro Creek is very low with typical sustained flow rates of less than 0.5 cfs. Higher instantaneous discharges can occur for short periods of time when the lagoon initially opens under low tide conditions.

2. Arroyo Burro Beach area is primarily subject to a westerly swell in both the summer and winter due to the more west-facing orientation of the beach.

3. Longshore currents along Arroyo Burro beach are predominantly from the west. A mean current speed of over five feet per second can occur during winter storms. Such strong longshore currents are less likely to occur during summer.

4. Surface layer water temperature off Arroyo Burro typically ranges between a low of 59 degrees during winter and a high of 64 degrees during summer/fall. Extensive mixing near the Arroyo Burro Creek mouth and nearshore is expected to prevent any significant temperature stratification close to the beach.

5. The summer-time discharge of Arroyo Burro Creek is not expected to form an exit jet due it's the low flow volume and velocities. The exit of the plume is expected to be largely associated with the ebbing tides that periodically flush the lagoon at the creek mouth. The exit plume tends to undergo substantial mixing by waves and tide-induced circulation at the mouth before being carried downcoast by the longshore currents.

6. The horizontal dispersion of the well-mixed exit plume mass by longshore currents is expected to be the primary mechanism of alongshore plume dispersal.

7. The bacteria counts are expected to experience appreciable decrease from die-off before exiting into the coastal waters due to the relatively long residence of the bacteria-laden freshwater in the lagoon as well as the gradual, cyclic process of tidal flushing. The die-off rate ranges from hours to days depending on the species and physical conditions of the water. However, this die-off may be offset by ongoing bacteria inputs to the lagoon from seabirds and waterfowl.

6.0 REVIEW OF SANTA MONICA BAY STUDY

As described in Section 2.2, when certain bacteria standards are exceeded, the County closes the beach for 400 yards on each side of the creek. The County selected the 400-yard limit based on the results of the 1996 study on the health effects on swimmers near storm drains in the Santa Monica Bay, entitled *An Epidemiological Study of Possible Health Effects of Swimming in Santa Monica Bay* (Santa Monica Bay Restoration Project, 1996). A brief summary of this study and its applicability to beach closure protocols in Santa Barbara are presented below.

6.1 SUMMARY OF SANTA MONICA BAY STUDY

The Santa Monica Bay Restoration Project conducted an epidemiological study of people who swam in Santa Monica Bay to address the basic question: Is it safe to swim in Santa Monica Bay? Years of monitoring established that demonstrated high levels of total and fecal coliform bacteria in the surf zone adjacent to storm drain outlets, and that there is a gradient of water quality at varying depths and distances from storm drains.

Three beaches were included in the study: Santa Monica Beach, Will Rodgers Beach, and Surfrider Beach. Persons who bathed in ocean water at these beaches were subjects of the study. Over 20,000 swimmers were interviewed on the beach to determine their eligibility for the study. The study targeted persons who bathed within 100 yards upcoast or downcoast of a storm drain, and those that bathed more than 400 yards from the storm drain. It was expected that the former subjects were exposed to potential pathogens associated with the storm drain discharges, while the latter subjects were expected to be outside the zone of influence of the storm drain, and therefore were considered "controls."

On the same day that subjects were recruited, water samples were collected in ankle deep water at the storm drain outlet, at 100 yards north and south of the drain, and at 400 yards north or south of the drain. The samples were analyzed for total coliform, fecal coliform, enterococcus, and *E. coli*. Nine to fourteen days after the recruitment, the subjects were interviewed again by telephone to ascertain the occurrence of fever, chills, ear ache, skin rash, diarrhea, and other symptoms. The study attempted to address two questions: What are the relative risks of specific adverse health effects in subjects bathing at the storm drain, within 50 yards, and within 50 to 100 yards compared to subjects bathing more than 400 yards away? Are the observed health effects associated with elevated bacteria indicators in the water?

The study showed that there were statistically significant increases in risk for fever, chills, vomiting, and other gastrointestinal illnesses and respiratory diseases for subjects bathing at a storm drain outlet compared to subjects bathing beyond 400 yards. The relative increase in risk for specific health effects ranged from 57 percent to 156 percent.

No increase in risk was observed for bathers within 100 yards of the storm drain compared to bathers beyond 400 yards unless the days when there were elevated bacteria levels beyond 400 yards were excluded. The rationale for excluding these days was to remove the effects of bacterial contamination of these waters from sources other than the storm drain.

The measurement of bacteria levels at 100 and 400 yards from the storm drains indicated that there was generally a significant decrease in the frequency of high bacteria concentrations immediately away from the storm drain outlets. Furthermore, the frequency of elevated bacteria concentrations generally decreased with distance from the storm drain. Table 5 displays this trend for the three beaches included in the study. However, bacteria concentrations were occasionally observed at 400 yards that equaled or exceeded those measured at the storm drain outlet. For example, there is little difference in the frequency of elevated bacterial levels at 100 and 400 yards at Santa Monica Beach (enterococcus) and at Surfrider Beach (total coliform). Furthermore, the frequency of high enterococcus levels was greater at 400 yards than at 100 yards upcoast at Surfriders Beach.

TABLE 5
FREQUENCY OF HIGH BACTERIA LEVELS AT AND NEAR STORM DRAINS

Bacterial Indicator	Percentage of Days when Bacteria Indicators Exceeded Thresholds*			
	Storm Drain Outlet	<100 yards of the Drain (upcoast)	<100 yards of the Drain (downcoast)	400 yards from the Drain (downcoast)
Santa Monica Beach				
Total coliform	44.3	12.7	12.8	3.8
Fecal coliform	11.4	3.8	3.8	1.3
Enterococcus	19.0	6.3	5.1	5.1
Surfriders Beach				
Total coliform	23.1	3.8	14.1	6.4
Fecal coliform	52.6	10.3	43.6	11.5
Enterococcus	51.3	19.2	48.7	21.8
Will Rodgers Beach				
Total coliform	46.6	5.5	5.5	0.0
Fecal coliform	56.2	6.8	8.2	1.4
Enterococcus	79.5	23.3	42.5	9.6

* Thresholds: total coliform=1,000 colony forming units; fecal coliform=200 cfus; and entrococcus=35 cfus.

These results indicated that either these areas are within the influence of the storm drain under certain wave and longshore conditions, or that these areas are receiving bacterial input from other sources. The study did not address the reasons for periodic high bacteria levels in areas more than 400 yards from the storm drain.

6.2 APPLICABILITY OF SANTA MONICA BAY STUDY

The Santa Monica Bay study clearly demonstrated an increased risk of certain health effects for subjects bathing adjacent to the storm drains discharging into the bay. The study provided insight into the use of bacterial indicators to predict health effects, taking into account total concentrations and ratios between indicators. The applicability of the study to our investigations are as follows:

1. There is evidence that bacteria concentrations decrease with distance from storm drains which are discharging contaminated water. However, the relationship between bacteria concentration and distance from the source observed in the Santa Monica Bay study was neither linear nor predictable.

2. Similarly, the Santa Monica Bay study provided evidence that the risks of certain illness decrease with distance from storm drains that are discharging contaminated water.

3. Based on the Santa Monica Bay study results, it appears that bacterial indicators can be dispersed as far as 400 yards from a storm drain outlet, most likely following the prevailing longshore currents.

4. The results of the Santa Monica Bay study cannot be directly applied to Arroyo Burro Beach for three reasons: (1) the discharge and level of pollution in the storm drains in Santa Monica Bay are significantly greater than at Arroyo Burro Beach; hence, the dispersal of bacteria may be greater at Santa Monica Bay beaches; (2) the wave direction and longshore currents differ between Arroyo Burro Beach and the beaches of Santa Monica Bay; hence, one cannot directly extrapolate the dispersal data from one beach to another; and (3) the pollutant sources in Santa Monica Bay were concrete storm drains, in contrast to Arroyo Burro Creek where the drainage is a creek with a lagoon where natural processes affect the bacteria loading to the ocean.

5. The study did not recommend beach advisory distances, nor imply that swimming at 400 yards from a storm drain would be risk free. The basis for selecting 400 yards as a "control" distance was not described in the study.

7.0 DISCUSSION AND CONCLUSIONS

The amount of data collected in this study is insufficient to perform statistical analyses. However, the data are sufficient to make several important observations. Bacteria levels generally decrease with distance from the mouth of the Arroyo Burro Creek due to dilution from mixing with ocean water and to mortality induced by increased salinity. The limited data suggest that the elevated bacterial levels observed at the creek mouth are not present beyond 300 yards under non-storm wave conditions with low creek discharges. Under certain circumstances, these elevated bacterial levels are also not observed beyond 50 yards of the creek mouth. It appears that creek water is primarily dispersed downcoast, causing higher bacteria concentrations east of the creek mouth compared to west of the creek mouth.

Oceanographic data indicate significant mixing of creek flows with ocean water occurs in the surf zone during the summer and that a well-defined freshwater plume is typically not formed at the creek mouth. In addition, the dynamics of the lagoon opening and closing are likely to have a greater influence on the mass of bacteria discharged to the ocean than the average daily creek flow. Finally, as noted above, the prevailing longshore current is likely to convey most flows to the east.

The results of the field investigations for this study are consistent with the findings in the Santa Monica Bay study. Both studies demonstrated a decrease in bacterial concentrations with distance, and that the dispersal of bacterial indicators was likely caused by longshore currents.

The high variability in the bacterial concentrations amongst sampling dates and stations indicates that numerous factors affect the dispersal, mortality, and concentration of bacterial indicators in the surf zone, even under low-flow, non-storm conditions. Because this variability is not yet understood, the development of a model to reliably predict bacterial levels at different distances from the creek mouth is currently infeasible.

The results of this study suggest that a narrower beach advisory zone may be appropriate for summer conditions at Arroyo Burro Beach, at least on the upcoast or western side of the creek. To ensure that a narrower advisory zone fully protects the public from bathing in water that exceeds the state's bacterial standards, the following actions should be considered by the County:

1. Sample Only When There is Flow to the Ocean

To the extent feasible, the County should collect the weekly sample only when the creek is discharging to the ocean in order to more accurately detect the input of bacteria to the surf zone and to determine the extent of dilution. If the creek flows are not reaching the ocean, then sampling should be postponed until later in the day or week. If creek flows are so low that flows are not expected to reach the beach during the week, then no sampling should occur because the bacterial loading under no flow conditions is expected to be minimal and only associated with seepage through the beach sand.

2. *Sample Later in the Week*

If possible, the sample should be collected as near as possible to the weekend when beach use is high. Three days are required for the field and lab work associated with initial and confirmation samples. Hence, the latest time to begin sampling prior to the weekend would be Wednesday.

3. *Collect Confirmation Samples at Varying Distances from Creek Mouth*

If the initial weekly sample exceeds the single sample standard, the County should collect the confirmation sample in front of the creek mouth, following the current protocol. However, additional samples should also be collected to delineate a narrower advisory zone based on measured bacteria levels. Confirmation samples should be collected 300 and 400 yards downcoast, and 50 yards upcoast of the creek mouth. The presence and absence of exceedances at these locations would provide the basis for delineating an advisory zone to be demarcated with signs warning beachgoers of elevated bacteria levels. If the bacteria concentrations at all three locations are less than the standards, the advisory zone would be restricted to the creek mouth. The advisory zone would extend to the other locations only if the bacteria levels at these locations exceed the standards.

4. *Continue to Collect Data on Bacterial Dispersal Distances*

The County should periodically sample at 50-yard intervals on either side of the creek to a distance of 400 yards to gather more data on the range of bacterial dispersal and to confirm the results of this study. The results of this additional sampling will provide more data to possibly narrow the advisory zone further than recommended above, and to identify conditions in which a narrower advisory zone would be inappropriate. The County should consider conducting a similar initial investigation at another beach to determine if the same patterns are observed elsewhere.

5. *Consider Permanent Signs at the Creek Mouth and Sampling at 25 yards*

The County should consider placing permanent warning signs about potential health risks at the mouth of Arroyo Burro Creek, and only sampling at a distance of 25 yards on each side of the creek to determine if an additional, weekly advisory is necessary. If there are exceedances of the single sample standard at 25 yards, the County would collect confirmation samples as described in Item 3 above to more precisely delimit the advisory zone.

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