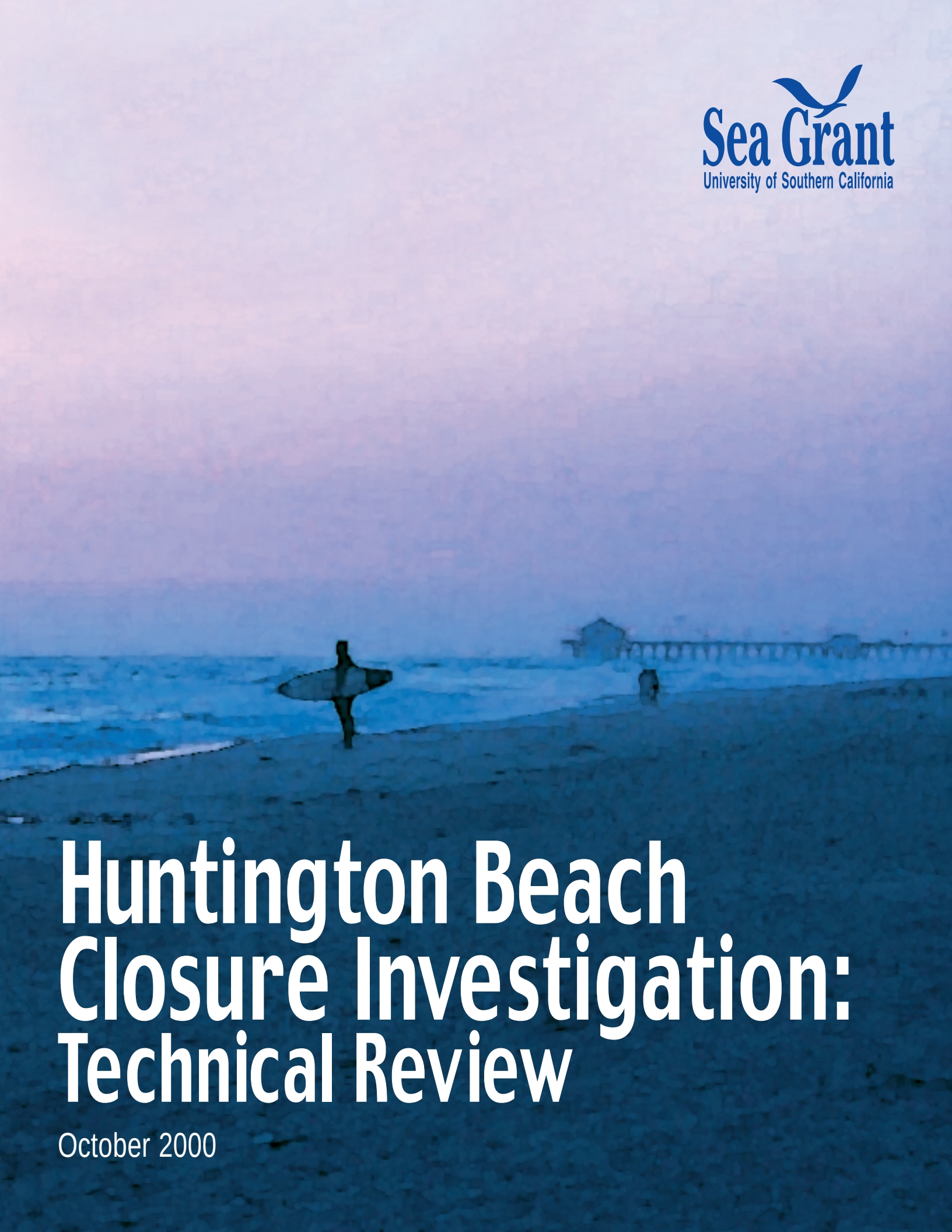

Sea Grant
University of Southern California

Huntington Beach Closure Investigation: Technical Review

October 2000

Acknowledgements

USC Sea Grant wishes to thank the members of the technical review panel who contributed to both the Huntington Beach closure public review and to this report. The panel, led by Dr. Stephen Weisberg, devoted a great amount of their time and expertise in producing this document. Their views reflect a vast resource of knowledge ranging from environmental engineering to microbiology.

We would also like to acknowledge the Orange County Sanitation District for requesting this review, and we thank all of the municipalities and agencies that participated: the City of Huntington Beach, Orange County Department of Public Works, Huntington Beach State Park, the County of Orange Health Care Agency, URS Greiner Woodward Clyde, and the State Water Resources Control Board. We hope this type of cooperative and forward-looking approach to better management of future beach contamination issues will serve as a model for other agencies and municipalities facing similar problems.

Editors: Judith Lemus, Ph.D. and Stephen Weisberg, Ph.D.

University of Southern California Sea Grant Program

USCSG-TR-01-2000

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INTRODUCTION

This report is the result of a technical review of the source investigation studies conducted during the closure of Huntington Beach in the summer of 1999. For a two-month period, large sections of Huntington Beach were closed due to excessive levels of indicator bacteria in the water. Because this closure occurred over such a large area during the peak summer season, it represents one of the largest known losses in the U.S. to recreational activities and revenues due to bacterial contamination. Approximately $2 million were spent in attempts to identify the source of the contamination.

The University of Southern California Sea Grant Program, at the request of the Orange County Sanitation District (OCSD), convened an independent review of the scientific studies and management actions that were undertaken during and subsequent to the beach closure. Ten experts from various disciplines wre invited to participate in the review during a three-day workshop held from February 28 to March 1, 2000.

The questions that were addressed during the review, and which will form the basis of this report, are:

1) Were the proper studies conducted and were the data properly interpreted?

2) What is the next set of studies that should be conducted near Huntington Beach?

3) What are the generic, longer-term research priorities that will facilitate future source investigations?

4) What are the lessons learned that could be transferred to others facing a similar challenge?

Prior to the workshop, the panel reviewed data and technical reports from investigations conducted by OCSD, the City of Huntington Beach, the Orange County Health Care Agency, and several independent contractors. During the workshop, managers and technical staff from these agencies gave presentations and were interviewed by the panel. The investigations focused on several major areas that will be referred to in this report: beach bacterial data; the OCSD outfall plume; onshore sewage pipes; groundwater sources; and urban runoff and coastal marsh sources.

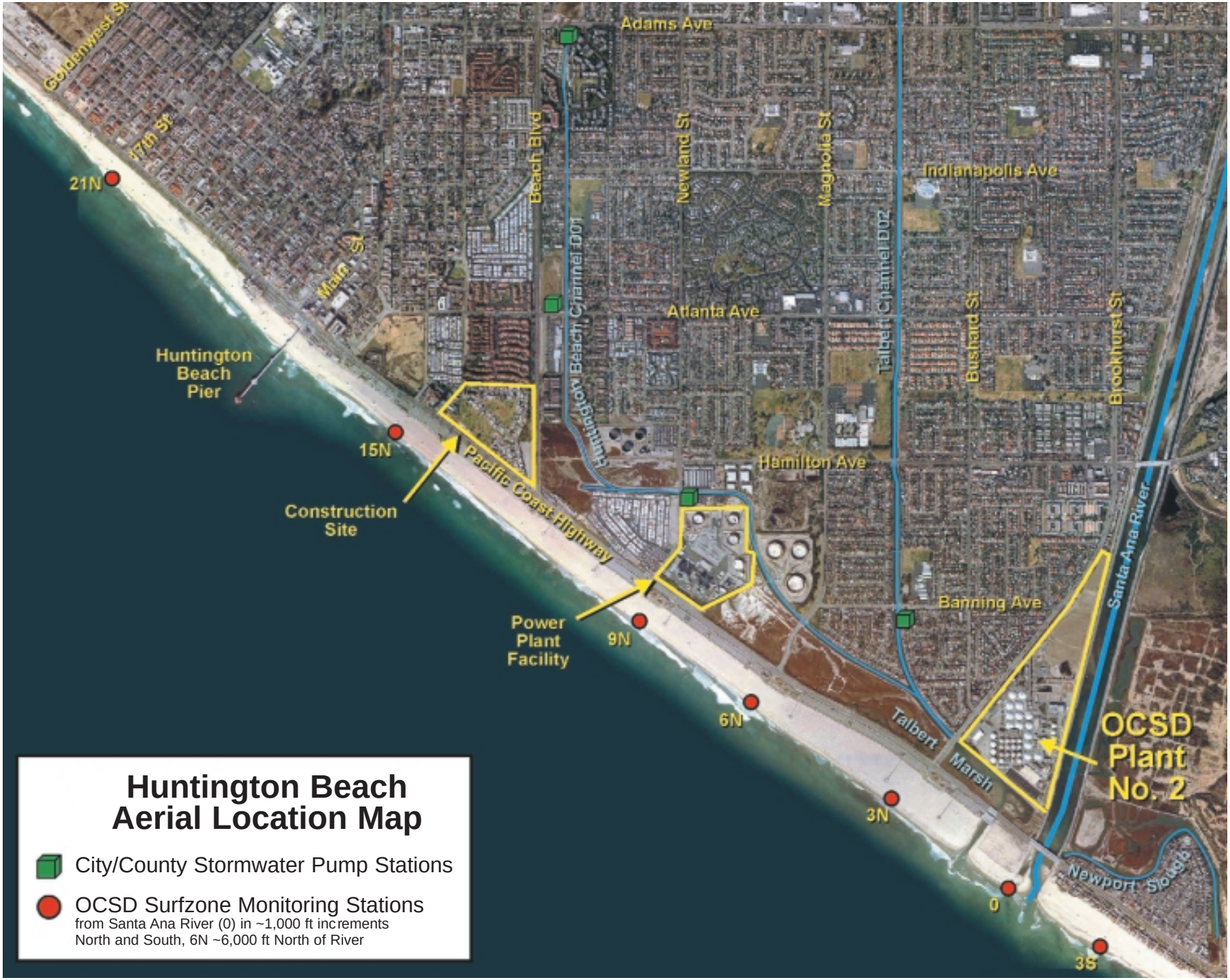
Huntington State Beach.

This report is a written summary of a public oral report given by the panel at the end of the three-day workshop. We hope that it will be useful to technicians and managers in identifying key areas that should be addressed both before and during a contamination event. While it is beyond the scope of this report to discuss policy and management measures that would prevent contamination spills, our aim is to help others reduce the impacts of these events by suggesting studies and procedures that will facilitate source identification and mitigation.

BACKGROUND/HISTORY

In response to the initial beach closing, a risk-based source investigation was initiated by OCSD, along with several other agencies: Orange County Health Care Agency, State Department of Parks and Recreation, the City of Huntington Beach, and the Santa Ana Regional Water Quality Control Board. Possible sources of bacterial contamination were prioritized according to: 1) their potential to contain human fecal material, and 2) the potential concentration of fecal coliform bacteria.

STUDY	DESCRIPTION	PURPOSE	TIME FRAME	RESULT
Picket Line	Water quality samples taken along a transect parallel to shore.	To determine if the OCSD offshore discharge was coming onshore.	May, July and August 1999	None of the samples had significantly elevated levels of bacteria.
Closed circuit television inspection of sewage infrastructure	Visual inspection of OCSD, Huntington Beach and State Park sewer lines.	To identify breaks, joint offsets or significant root infiltration that could cause leakage.	June 30 to October 7, 1999	Identified breaks were repaired, with no effect on beach contamination levels.
Monitoring Wells	Groundwater sampled from five 30 to 60-foot wells via peristaltic pump.	To determine if there was a plume migrating to surf zone from Coast Trunk line or other facilities.	July 29-30	No contaminated samples were found.
Hydropunching	Using a hydraulic ram, near-surface groundwater was sampled via a peristaltic pump.	To determine if the bedding around sewer lines, power plant lines, or local groundwater was functioning as a transportation mechanism for bacterial contamination.	August 9-28, 1999	No contaminated samples were found.
Offshore triangle	Water quality samples were collected simultaneously from sites along the beach, along the outfall pipe and from different depths along three offshore transect lines.	To determine if the offshore portion of the OCSD outfall pipe was contributing to the beach contamination.	August 13, 1999	Offshore samples did not contain significantly elevated levels of bacteria.
Talbert Marsh (TM) and Santa Ana River (SAR) water quality and citrus studies	Water quality and nutrient parameters were monitored throughout TM and over outfall. Grapefruit and oranges were dropped at the ocean outlets of TM and SAR and tracked.	To determine if a transport mechanism to surf zone existed for the effluent water from TM and SAR.	August 30 and September 16, 1999.	Many of the fruit washed ashore onto Huntington Beach in the areas of highest bacterial counts. The water quality results did not confirm the physical info from the citrus study.
TM and SAR overnight studies	Densities of all 3 indicator bacteria were measured at the outlets to TM and SAR at 30 min. intervals overnight.	To determine whether bacteria leave TM or SAR at low tides and enter the surf zone.	September 8-9, 1999	Inconclusive - high bacteria levels on the beach did not correlate with water samples collected at the TM and Santa Ana River outlets.
Dye studies	Rhodamine dye was injected into the effluent and tracked from the OCSD outfall pipe.	To determine if the nearshore (buried) portion of the OCSD outfall pipe was leaking and to track the offshore plume.	September 30, 1999	No evidence of dye shoreward of the diffuser (offshore) portion of the pipe. Offshore plume was tracked moving downcoast and shoreward.
UCI Talbert Marsh tidal transport study	Hydrology, bacteriology and chemistry of water flowing in and out of TM was characterized.	To determine if the Talbert Watershed is a significant source of indicator bacteria to the nearshore area of Huntington Beach.	December 7-21, 1999	Pump station discharges increased the nearshore loading of total coliforms, but timing and magnitude of loadings were affected by a number of parameters. TM also appeared to be a significant source of episodic nearshore loading of Enterococcus during the study period.


Huntington Beach Aerial Location Map
City/County Stormwater Pump Stations
OCSD Surfzone Monitoring Stations
from Santa Ana River (0) in ~1,000 ft increments
North and South, 6N ~6,000 ft North of River
Adams Ave
Goldenwest St
17th St
Beach Blvd
Newland St
Magnolia St
Indianapolis Ave
Main St
Huntington Beach Channel D01
Talbert Channel D02
Bushard St
Brookhurst St
Atlanta Ave
Hamilton Ave
Banning Ave
Santa Ana River
Pacific Coast Highway
Talbert Marsh
Newport Slough
21N
15N
9N
6N
3N
0
3S
Huntington Beach Pier
Construction Site
Power Plant Facility
OCSD Plant No. 2

I. Were the proper studies conducted and were the data properly interpreted?

Overall, the panel was impressed by the level of effort expended by the local agencies in response to this contamination event. Given that OCSD is a sanitation district, the panel recognized that their logical first concern was to insure that the contamination was not caused by sewage. They felt that the investigations of sewer lines and groundwater contamination pathways were thorough and that the studies were properly conducted. Later investigations that focused on the stormwater drainage systems and the offshore plume were more limited in scope, as these studies tended to be intense spatial surveys conducted for short periods of time. The panel was able to identify several ways in which these latter studies could have been improved, but the panel recognized that they had the advantage of viewing the situation in hindsight. Given the short time period in which decisions had to be made, and the economic, political and public relations pressures that needed to be dealt with simultaneously, they felt that management authorities in Orange County should be commended for the intensity and breadth of their response.

The panel also thought that the data were properly interpreted. There were three primary sources of contamination that were considered during the investigations: the onshore sewage pipes, the offshore sewage outfall, and the stormwater drainage systems. The panel thought that local officials reached the proper conclusion that drainage from land-based sources was the most likely source of the contamination in August and September.

Onshore Pipes And Groundwater

The onshore sewage pipes along the beach were an obvious source of potential contamination, but the studies conducted convincingly eliminated this possibility through three lines of evidence: 1) A lack of volume lost in any of the metered pipes; 2) thorough inspection using pressure testing and CCTV of all pipes that were potential sources; and 3) the absence of bacterial contamination in the numerous groundwater samples collected.

The panel further thought that while pipe leakage into groundwater needed to be investigated, it was not a likely source given the bacterial patterns observed on the beach. Groundwater flux occurs too slowly to cause the large spatial scale of contamination that occurred on the beach. Also, it is a relatively consistent source once contaminated and is unlikely to produce the high degree of temporal variability in bacterial concentrations observed along Huntington Beach.

Offshore Sewage Outfall

The panel concurred that onshore transport of the OCSD outfall plume was an unlikely source of the beach bacterial contamination based on three lines of evidence: 1) There was a strong thermocline in the area during the period of the beach closures, which would keep the plume submerged and away from shore; 2) None of the samples collected in the picket line studies conducted 1000 m from shore contained high bacterial concentrations; 3) Normal dispersive processes associated with plume transport suggest that the observed contamination on the beach would be spread over broader spatial scales; and 4) The plume had never been observed to come to the Huntington Beach shore in more than 20 years of monthly plume tracking studies.

Stormwater Conveyance Systems

The panel concluded that the Talbert channel stormwater conveyance system was the most likely source of bacterial contamination along Huntington Beach based on four lines of evidence: 1) The high bacterial concentrations that were found in the stormwater forebays and which were subsequently pumped into the conveyance system; 2) The citrus studies that tracked the transport of Talbert Channel discharge water onto the contaminated beach areas; 3) The tidal signature of the beach contamination was consistent with tidally influenced drainage from land based sources; and 4) Diversion of stormwater from pump stations upstream of Talbert Marsh into the sewage system mitigated almost all of the beach contamination.

While the panel felt that drainage from the Talbert Channel was the most likely source of bacterial contamination to the beach, they also expressed concern about three unresolved issues that limit the strength of this conclusion. First, in none of the sampling was there a spatial pattern of decreasing contamination concentration from the channel to the contaminated beach. The panel suggested several transport mechanisms that could account for the lack of a clear concentration gradient, but the studies that were performed did not allow for evaluation of these hypotheses. The next section of this report identifies some of the studies that should be conducted to retrospectively evaluate these mechanisms.

Second, there was limited evidence that sand on the beach across the entrance to Talbert Marsh limited tidal exchange between the Talbert Channel and the ocean during the initial period of beach contamination. The panel placed less emphasis on this evidence, as the direct observations were anecdotal and conflicted with the fact that samples were taken at the Talbert Channel soon after the contamination occurred. There was secondary evidence of blockage from the lack of tidal influence at the gauging station upstream of the marsh, but the gauge was located far enough from the mouth that exchange was probably limited. Given the importance of this information, documentation of flow from land based sources was one area that the panel thought should have been improved during the investigations.

Third, there was limited bacterial data for the Santa Ana River, which could have also been a source. The panel felt that the Talbert Channel was the more likely source, but the limited data collected from the Santa Ana River (at 2.5 miles upstream) had fecal/total coliform ratios that were similar to those found on the beach. If the Talbert Channel outlet was bermed, perhaps the Santa Ana River was the source of the initial beach values.

Better Contaminant Characterization

While the panel generally felt that the appropriate studies were conducted in this emergency situation, they also felt that the investigation could have been improved in a few ways. The first of these is better contaminant characterization. The initial decisions to close the beach, as well as the direction of the subsequent investigations, were based largely on the presumption that sewage was the primary source of the beach contamination. This conclusion was reached based on the high concentration of all three indicator bacteria measured and the low total:fecal coliform ratio. While the panel agreed that local officials correctly used this information to guide early decisions, this was an important assumption. Without it, the beach might have been posted with warning signs, rather than closed. Also, the presumption about source led to investigations that focused on sewage, rather than on urban runoff. Focusing on potential sewage sources at an early date was certainly warranted from a health risk-based approach, but the assumption led to limited data collection from runoff sources during the early parts of the investigation. Given the importance of these decisions, the panel suggested that a greater level of contaminant characterization was warranted.

Talbert Marsh outlet to the ocean at the south end of Huntington State Beach.

The panel suggested numerous characterization techniques that could have been used:

1) Speciation

Currently-performed routine monitoring for the presence of indicator bacteria such as total and fecal coliforms, and enterococci do not address questions of whether the source bacteria are human- or animal-generated. Some new methods have recently surfaced that address this issue. Methods such as ribotyping, DNA fingerprinting, antibiotic resistance, and PCR have been used to further characterize the types of bacteria found in samples, and to determine whether they came from human or animal fecal contamination. Not all of these tests determine the presence of pathogenic or "disease causing" organisms, and therefore are not an indication of public health risk. Rather, they are tools to determine the source of contamination, and move a step beyond the currently used bacterial indicator tests.

2) Viral testing

Bacteria, viruses, and protozoans can all be causes of disease from contact with contaminated waters. However, currently enforced regulations only require the testing of bacterial indicators as a measure of microbiological water quality. Specific types of viruses are both causative agents of a significant portion of waterborne disease and indicators of the presence of human fecal contamination. Molecular methods such as Reverse Transcriptase Polymerase Chain Reaction can be used to detect specific groups or families of viruses. These tests are highly sensitive, can be performed in less than one day, and can provide important information as to the presence of human fecal matter.

3) Chemical markers (LABs, Coprostanol)

Scientists have also used chemical markers, such as linear alkyl benzenes, caffeine, sterols, and immunoglobulins to identify sewage as the source of fecal pollution. While the sensitivity of these methods can be affected by dilution, they can be reliable markers of a sewage source when detected.

The panel recognized that their suggestion of better characterization was easier for them in hindsight than it would have been for participants at the time of the event. Most of the techniques above are relatively new, expensive, and still in the research phase. Perhaps more important, most of these tests are not rapid, often requiring several days to weeks of laboratory work before results are obtained. The history of beach closure events within the county had been short-term definable events in which the sources had always been identified in shorter time frames than it would take to get results from these specialty tests. Still, at some time during the event, probably after a week or two, there should have been a realization that this event was different and challenging enough to warrant the use of non-traditional tools. Use of these tools would not have led to a different conclusion, though it might have allowed local officials to reach their conclusion sooner.

Animal Sources

The panel felt that local officials should have expended more effort to ensure that animal sources, particularly shorebirds or local pets, were not the bacterial source. While the panel believes that birds were an unlikely source due to the reportedly low bird densities, they were concerned that the information about bird density was too sparse and anecdotal for such an important problem. Also, feces from the local pet population can enter the stormwater conveyance system and hence, be transported to the shoreline. The panel believed that one of the reasons that animal sources were so poorly characterized is the presumption that human sewage was the primary source of the problem.

Sampling Strategy

The panel felt that the episodic nature of the contamination suggested the need for selectively increasing the spatial and temporal sampling density at some time during the investigations. The panel had a difficult time making this recommendation, given the extremely large numbers of samples collected, but they also felt that the beach sampling focused more on determining the spatial extent of the closure than it did on source investigation. For instance, during the investigation sampling occurred at 12 hour intervals, which is certainly intensive, but is still insufficient to assess the importance of tidal influence. The panel

would have preferred exchanging some of the routine 12 hour intensity for sampling at hourly or bihourly intervals to address not only the tidal effect, but the persistence of a contaminant patch over a daily cycle. Similarly, there was considerable sampling along the beach, but almost no sampling of cross-shelf transects. Cross-shelf transects could have provided additional evidence for the drains as the source if contamination was limited to cross-shelf sites closest to the beach.

II. What are the next studies that should be conducted near Huntington Beach?

The next steps taken by local officials are likely to include mitigation procedures designed to prevent urban runoff from entering coastal waters during dry weather periods. These measures may include diversion of urban runoff to the treatment plant, buffering exchange between the marsh and the beach, or changing land use practices to minimize runoff. However, since these measures can be expensive and because there remain some unresolved concerns about the Talbert channel as the source, the panel recommended several studies that should be conducted to increase certainty about the bacterial source before long-term control measures are implemented.

Nearshore Transport

The panel felt that the most pressing need was for studies of nearshore hydrodynamic processes, including mechanisms that could transport water-borne contamination along the shore. The panel was concerned that none of the samplings demonstrated a bacterial concentration gradient between the marsh, the Santa Ana River, or the offshore plume and the affected beach areas. Moreover, to accept any of these as the likely bacterial source, one has to accept that the bacteria could move four miles upcoast with minimal dilution. The few nearshore transport studies that have been conducted suggest a much higher plume dispersion rate.

The recommended studies include dye releases, an expanded set of nearshore transport measurements and nearshore transport modeling. The panel agreed with the presenter who suggested that the $60 invested in the fruit transport study was one of the better ways money was spent during the investigations, as it demonstrated that material in the near-surface portion of the plume from the Talbert Channel could reach the affected beach area. More sophisticated dye studies that examine the three-dimensional structure of the marsh plume and its dilution under a variety of tidal, wind and wave conditions is a logical next step in understanding nearshore transport of Talbert Channel waters. Modeling efforts to aid in understanding these processes are also warranted. Some plans for nearshore transport modeling were presented to the panel. The panel agreed that development of nearshore transport models is warranted, but expressed concern that the proposed one-dimensional model with limited real-time data assimilation capacity would not be sophisticated enough to address the nearshore transport issues.

The panel also suggested that future studies consider other transport mechanisms. One suggested hypothesis is that bacterial transport along the beach could occur via attachment to particulates or to surface foams. Attachment to particulates might explain the minimal dilution observed and might account for the tidal signature in beach bacterial levels, as particles would be deposited along the high tide mark and accumulate along the shore. These transport mechanisms would not be assessed through traditional dye or modeling studies.

Understanding Marsh Dynamics

While the panel concluded that the Talbert Channel was the most likely source of the beach's bacterial contamination, they were uncertain about the role of the marsh as a bacterial source. The marsh could possibly serve as a bacterial source by attracting and aggregating birds and other wildlife, and could enhance bioaccumulation and survival of microorganisms due to low salinity and oxygen. Alternatively, it may be only a neutral conveyance system through which

contaminated upstream waters reach the ocean. It is also possible that it serves as a filter, reducing the amount of bacteria originating from upstream sources. Another possibility is that it serves as a storage system in which bacteria deposit on the bed at low velocities and are resuspended and flushed out at faster velocities that occur with high tides. Understanding which of these mechanisms is predominant can help ensure that the most effective management solution is chosen. Understanding marsh-bacterial dynamics is also a question that extends beyond this particular site. One aspect of restoring Talbert marsh was to relocate its tidal connection to the ocean from an indirect route through the Santa Ana River to a direct connection to the ocean across the beach. Similar tidal circulation enhancements are likely to be considered in other marsh restoration projects in Southern California and a better understanding of the role of marshes in bacterial dynamics may improve the efficacy of these projects.

Develop A Plume Model

While the panel felt that the offshore discharge plume from the Orange County Sanitation District was an unlikely source of the beach closures, they also felt that there should have been real-time data that allowed definition of the predominant current direction and location of the plume at any time during the investigation. Because ocean circulation patterns can change quickly, real-time data on thermocline strength, current direction and wind patterns, coupled with an analytic or numerical model of local ocean circulation processes, would provide better assurance that the intermittent water quality excursions on the beach were not the result of intermittent upwelling or changes in plume direction.

Such systems could include a combination of real-time moored systems such as those now being deployed by OCSD, and might also include fly-overs or satellite imagery (infrared, SeaWiFS, and radar) which could be used retrospectively to further determine whether upwelling events ever occurred during times of beach closures. The system should provide for measurements of currents and density stratification over the water column. The telemetered data should be used as input to a real time plume model to provide guidance on plume behavior. The panel also felt that plume definition should extend beyond the dissolved material signature of the plume and consider buoyant particle dynamics, such as grease particles. One possibility to consider is that bacterial particles attached to grease, which can float through the thermocline layer and then be transported to shore via surface currents. The panel thought this hypothesis was unlikely, as bacteria levels were low in the picket line studies and there was no evidence of bacterial attachment to buoyant particles in any of OCSD's historical offshore sampling, but the theory is plausible enough to warrant addressing as part of plume definition studies.

III. What are the generic, longer-term research priorities that will facilitate future source investigations?

Many of the challenges in responding to the Huntington Beach closure resulted from inadequate knowledge of basic coastal processes and from the need for better investigational tools. These difficulties extend beyond Huntington Beach to other closure situations and can only be resolved through investment in proactive research to develop these tools before they are required at the time of an investigation. The panel identified seven research areas that, if implemented, should improve the speed and accuracy of future closure investigations.

Better source characterization methodologies

One of the critical decisions in the Huntington Bach investigations was whether the bacteria originated from a human source. If the source was human, then the source investigations would have focused on potential leaks from the onshore sewage transport infrastructure or on flow from the offshore outfall; alternatively, if the source was non-human, the investigations would have focused on land-based runoff or animal populations near

the beach. Most investigations of short term events presently rely on the ratio of fecal to total coliform bacteria to make this determination. This is an inadequate tool when the economic resources of a beach community depend on rapid and reliable mitigation of the problem.

Several new techniques have the potential to provide direct evidence of source origin, but all are in the early stages of development and require further testing before they can be relied on as a core technology. For example, antibiotic resistance profiles of bacteria have been used to differentiate between human and non-human fecal sources, since the bacteria that infect people and livestock are often resistant to different antibiotics. However, this method has been tested in only a few areas of the country. Biologists are already using highly discriminatory DNA fingerprinting techniques, such as Pulsed Field Gel Electrophoresis, to identify microbial disease agents in water and seafood; however, a shared library of gel patterns that can be used to identify a high percentage of the samples doesn't yet exist. Methods involving polymerase chain reaction (PCR) and DNA microarrays are being developed, but are still expensive and require specialized technology that is not available in the typical microbiological laboratory. Moreover, all of these new methods require further testing on environmental samples (especially those from nearshore marine environments) which present challenges due to their variability in salinity, temperature, enzymes, dissolved organic matter, total suspended solids, etc.

Understand the relationship between indicators and pathogens

The decision to close Huntington Beach was based on the assumption that the high bacterial counts originated from a human source. While there are certain pathogens that only originate from human sources, the relationship between indicator bacteria and pathogens is poorly understood, particularly for bacteria associated with urban runoff. Health departments continue to rely heavily on indicator bacteria because they are more rapid and less expensive to measure than pathogenic microbes, but this reliance requires a better understanding of the relationship between concentrations of indicator bacteria and the presence of pathogens of concern, including those from non-human sources. This can be accomplished through correlative studies in which indicator bacteria are measured simultaneously with pathogenic bacteria and viruses from a variety of different source materials. Additionally, these studies can be combined with epidemiological investigations to link indicators and pathogens to potential public health risk.

Better nearshore transport models

One of the difficulties that the Huntington Beach investigators faced in defining the source of beach bacteria resulted from a limited understanding about transport of water, particulates and pollutants through the surf and nearshore coastal zone. Most physical oceanographic studies have focused on large-scale offshore circulation patterns that are driven by longer term meteorological patterns. Few studies have examined coastal shelf circulation processes and even fewer have studied their interaction with nearshore sources in the surf zone. Near coastal processes can be complex, confounded by local topography and short-term weather patterns. However, transport models are essential for helping to direct source investigations and are also necessary to better understand the conditions that would permit shore-based discharges to move along the surf zone with minimal dilution.

Adherence of bacteria to particles and surface films

The studies conducted at Huntington Beach were based on the assumption that the bacteria move through the water column as if they were in solution. An alternative hypothesis is that bacteria adhere to particles, in which case their movement could differ from simple water movement patterns. Depending on the size of particles to which they were attached, bacteria could potentially be transported as part of bed load, or could be deposited on the beach at high tide. These different dynamics would affect transport rates and impact bacterial distribution and concentrations. Similarly, bacteria from the OCSD outfall were thought to remain offshore because of the density barrier imposed by the thermocline. While this would be true for dissolved materials, it might not be true if bacteria adhered to oil droplets and floated to the surface. At low enough

densities, these materials would not be apparent as a sheen but could still be transported towards shore under the proper wind conditions. Addressing these hypotheses requires studies to determine the extent to which bacteria attach to particles and, if so, to what size and type of particles.

Rapid detection techniques

Currently used methods for both speciation and characterization of bacterial species in beach waters generally require around 24 hours, a limitation imposed by the use of culturing techniques. Culture techniques, although decades old and well-established, are limited because of the long incubation time required for bacterial growth. New molecular methods involving polymerase chain reaction and DNA microarrays have the potential to considerably reduce the time for bacterial results to be reported. This time reduction will improve the health department warning systems. Whereas warnings are presently provided 24-48 hours after the sample is taken because of the culturing time, new rapid techniques may take less than an hour and provide the opportunity for same day warnings to the public. With respect to source investigations, rapid techniques will provide the opportunity to follow a source in near-real time. This can be particularly advantageous in circumstances such as occurred at Huntington Beach in which the gradient patterns are tidally influenced and hard to define by sampling at preselected times.

Better characterization of urban runoff sources

Urban runoff was cited by the Panel as the most likely source of the Huntington Beach bacterial contamination. The City of Huntington Beach has responded by diverting their runoff to the OCSD treatment plant during the summer months, which is an effective treatment of the symptom, but not the cause. Addressing the cause requires identification of the upstream sources, which has not yet been attempted in Huntington Beach and has not been successfully accomplished in many watersheds where it has been attempted. Successful upstream source identification will require development of sophisticated runoff models and land-use specific runoff characterization studies necessary to populate these models. Similar models have been developed in temperate regions of the country where runoff is moderated by rainfall events, but considerably more focus is needed in the arid southwest where human activities such as over-watering of lawns and washdown are the principal sources of freshwater conveyance.

Role of marsh in bacterial dynamics

Many southern California marshes have been hydrologically altered through land development and no longer have a tidal connection to the ocean. Many of the potential marsh redevelopment projects in Southern California involve restoring or enhancing tidal circulation. Marshes are often thought of as natural filters that serve as effective buffers between land-based sources of pollution and the ocean, but several presenters to the panel expressed concern that restoring tidal circulation, such as occurred in the Talbert Marsh restoration, yields new or enhanced ocean outlets for upstream urban runoff. Concerns were also expressed that marshes may attract birds and other mammals, which are sources of bacteria. Currently, there is little scientific information to assess whether marsh restoration projects improve ocean water quality because the fate of bacteria that enter marshes from animal or upstream sources is poorly understood. Developing a scientific foundation for the role of marshes in bacterial dynamics is a necessary precursor

South facing view of Talbert Marsh

for assessing and addressing concerns expressed about the value of marsh restoration projects.

IV. What are the lessons learned that could be transferred to future events in Huntington Beach or elsewhere?

Previous discussions in this report have focused on the summer 1999 event at Huntington Beach. This section outlines some of the lessons that the panel felt had application to similar events occurring at other times or in other places.

Contingency Plans

While most of the proper studies were conducted during the Huntington Beach investigations, most of the decisions were made on an ad hoc basis. No contingency plans were in place and there was no clear delineation of who was responsible for leading the effort. Many of the participants met each other for the first time during the investigations, when quick decisions were necessary.

The panel recommended that all counties and municipalities develop contingency plans for such events. These plans should clearly identify the roles and responsibilities of all parties, and include a decision tree that outlines the procedures to be followed under various contamination scenarios. The State Water Resources Control Board is presently developing guidance documents for tracking the sources of beach bacterial contamination that should be helpful in this part of contingency planning (this guidance is required from the State Board in response to Assembly Bill 538).

Part of defining roles and responsibilities is identifying whether, and which, local organizations have the laboratory capacity to support source investigations. Even counties with substantial laboratory capacity, such as Orange County, may still need additional support with specialty analyses. Trying to identify and develop contractual relationships with outside laboratories or university specialists can cause unnecessary delays in the investigations if they are not initiated well in advance.

Part of contingency planning is developing an integrated data base that would include GIS mapping of all sewage pipes and storm drains. In the Huntington Beach investigations, knowledge about different aspects of these systems resided within different organizations and this transfer of knowledge was inefficient for supporting real-time decisions. For instance, the Orange County Sanitation District led most of the studies, but they have no responsibility for storm drain maintenance and were not even aware of the existence of the Talbert Channel storm drain forebays until late in the investigations.

Another part of contingency planning is selecting an organization to lead the investigation. Although the panel complimented the work, they questioned whether the OCSD was the proper leader for the Huntington Beach investigations. Even though OCSD has outstanding laboratory facilities and a well-trained staff, their main responsibility in this situation was to determine whether a sewage leak was the cause. The panel wondered if an organization that had primary responsibility for storm drains had led the investigation whether it would have started with, or moved more

Talbert Channel D2 adjacent to the Banning Ave. Storm Water Pump Station

quickly to, a focus on urban runoff sources. The panel recommended that the leadership role is more appropriately placed with a regulatory or public health agency with responsibility for looking across all sources.

A Comprehensive Monitoring Program

The problem at Huntington Beach was quickly identified because Orange County has an ongoing comprehensive monitoring program. Orange County beachgoers should be assured that they can swim safely because of this program, which samples several times per week during the summer and measures three indicators, making it one of the most comprehensive programs in the nation. In most others areas of the country, swimmers would not have been appropriately protected. There are several states, and many individual counties outside of California, which do not have any ongoing beach water quality monitoring programs. This should be corrected, as the problems encountered at Huntington Beach are not unique to that location.

While Orange County's monitoring program for assessing beach health is good, its monitoring of upstream watersheds is poor and is not coordinated with its coastal water monitoring. Such programs should be coordinated. Several studies have shown that urban runoff and non-point source pollution are a major cause of impaired coastal water quality. Routine sampling should be conducted to characterize all potential sources of bacteria entering the ocean. Similarly, critical sources of pollution within watersheds should be identified and monitored before a crisis event. In Huntington Beach, routine monitoring of forebay discharges might have led to early focus on, and action to reduce risk from, the upstream sources.

Routine Maintenance of Piping Infrastructure

The piping systems that transfer sewage to treatment plants are important potential sources of bacterial contamination. In the Huntington Beach investigations, much expense and effort was spent to eliminate these pipes as the source of contamination. While better source characterization may have lessened the need for these studies in Huntington Beach, the large expenditures and concern about this potential source underscores the need for a preventive inspection and maintenance schedule to ensure confidence in the integrity of the sewage pipes before a spill event occurs. Much of the piping infrastructure in Orange County, as in other areas of the country, is old and in need of continuing maintenance. Visual inspection by means of closed circuit TV is a direct and effective method for monitoring pipe integrity. Metering systems located at strategically placed locations in the system would allow real-time assessment of system integrity.

Independent Decision-Making

The panel commended the Orange County Health Department for their courage and perseverance in making beach closure decisions to protect public health. The circumstances surrounding their decisions were difficult: the contamination was intermittent, the data supporting whether this was a sewage spill were equivocal, particularly later in the event, and there was strong economic pressure to keep beaches open. There can be arguments made that the beaches could have been posted with warning signs instead of closed in August and September, but the panel felt the proper decisions were made and that the Health Care Agency was the appropriate lead in these decisions. In public health matters, conservative measures are warranted.

Even more important than the decision itself, the panel was highly complimentary of the County for relying on its experts and insulating the decision from the political process. In the short term, the decisions were painful to local businesses and met with some political resistance. However, in the long term, the citizens of Orange County and their visitors should feel comfortable that when their beaches are open they are truly clean. Independence creates credibility, which is too important to risk in the vital tourism industry. Independence also ensures that the political forces remain focused on solving the problem, rather than on debating the symptom.

Technical Review Panel

ALFRED P. DUFOUR
Director
Microbiological and Chemical Exposure Assesment Research Division

Dr. Dufour received his Ph.D. in bacteriology from University of Rhode Island and his M.P.H. from Yale University. Currently he is the director of the Microbiological and Chemical Exposure Research Division, Environmental Protection Agency, National Exposure Research Laboratory, Cincinnati, Ohio. He holds an adjunct professor appointment in the Department of Civil and Environmental Engineering and the University of Cinncinati. Dr. Dufour has served on dozens of committees and working groups pertinent to water quality and environmental health. He is currently a member of the working group on waterborne Cryptosporidiosis through the Centers for Disease Control and Prevention. Dr. Dufour has received six EPA awards, was awarded a patent, and has been involved with many national and international organizations, including World Health and the Pan American Health Program.

JERRY ALAN GALT
Chief
HAZMAT, NOAA

Dr. Jerry Galt was the Chief of the Hazardous Materials Response Division (HAZMAT) of the Office of Response and Restoration in the National Oceanic and Atmospheric Administration (NOAA) until his recent retirement. He has worked for NOAA since 1973. He directed a multi-disciplinary program combining theoretical research and real-time applications at accidental spill scenes. His Division works to maintain a state-of-the-art capability in tracking the fate and effects of pollution on both the water and in the atmosphere. He has directed the modeling component of spill response, including forecasting pollutant trajectories with respect to specific areas or biologically important environments, to well over one thousand oil and chemical spills during his career. Under his direction, microcomputer-based models have been developed to estimate pollutant movement and effects in the air and water.

Dr. Galt graduated from the University of Washington in 1963 with a B.S. in physics, received a M.S. in Oceanography in 1967, a B.S. in math in 1967 and a Ph.D. in Physical Oceanography in 1969. From 1970-1973 he served as an assistant professor at the Naval Postgraduate School in Monterey. From 1974 to the early 1980s he was an affiliate professor in the Oceanography Department of the University of Washington.

MARK GOLD
Executive Director
Heal the Bay

Dr. Mark Gold is the Executive Director of the local environmental group, Heal the Bay. Founded in 1985, Heal the Bay is a non-profit group of more then 10,000 members working through a combination of research, education, public outreach and advocacy to make Santa Monica Bay and Southern California's coastal waters safe and healthy for people and marine life. Dr. Gold completed his doctoral dissertation in UCLA's Department of Environmental Science and Engineering and has since worked on a wide variety of water quality and coastal natural resources issues ranging from sewage treatment to contaminated sediments to wetland restorations. He is considered one of the region's foremost experts in urban runoff pollution, and influences governmental water policy at the local, state and federal levels.

MARLENE A. NOBLE
Research Oceanographer
U. S. Geological Society

After receiving her Ph.D. in Physical Oceanography from University of Rhode Island in 1983, Dr. Noble began her tenure at the U. S. Geological Survey, Menlo Park, CA. She has been designing and implementing research programs to study circulation on the continental shelf and within submarine canyons for over 25 years at USGS in Woods Hole, MA. Dr. Noble has published extensively, notably receiving the best-published paper in the Bulletin of the Association of Engineering Geologists, 1994.

Dr. Noble developed a program in 1992 to determine the circulation and sediment/pollutant -transport pathways on the Palos Verdes shelf and within Santa Monica Bay. Information obtained has been used in the ongoing federal lawsuit against DDT manufacturing companies. Also, results from the programs in Santa Monica Bay will help us determine the rates of sediment or pollutant transport in the region and the reasons that deposits of fine sediments have widely varying thickness along similar isobaths.

RACHEL NOBLE
Researcher
Southern California Coastal Water Research Project

Dr. Rachel T. Noble shares a joint position as an environmental microbiologist for both the Southern California Coastal Water Research Project (SCCWRP) and USC's Wrigley Institute for Environmental Studies (WIES). Dr. Noble has performed research on the roles of native marine virus populations in marine microbial food webs, and also on the detection and fates of human pathogenic viruses and bacteria in the coastal ecosystem. Dr. Noble has recently been one of the coordinators for large scale studies on the shoreline microbiology that examine potential public health risk due to human pathogens along the shores of Southern California from the Mexican border to Santa Barbara. In addition, she has been involved in the development of novel techniques for the rapid and quantitative detection of human pathogenic viruses in the coastal waters of southern California.

ERIC REICHARD
Coastal Program Chief
USGS Water Resources Division

Dr. Eric Reichard received his B.A. in Economics from the University of Rochester and his M.S. and Ph.D. in Geohydrology from Stanford. He served as a research fellow at the Harvard School of Public Health. Currently, Dr. Reichard is the Coastal Program Chief for the USGS Water Resources Division, California District. His research interests include geohydrologic modeling, groundwater management, and environmental risk assessment. Dr. Reichard was the project chief for the Coachella Valley Study, Oxnard Plain Optimization Study, and the Santa Clara River Study. Since 1995, he has been the project chief for the Los Angles Basin Groundwater Management Study that analyzes geohydrology and geochemistry of Los Angeles and evaluates alternative water-management plans.

PHILIP ROBERTS
School of Civic and Environmental Engineering
Georgia Tech Universtity

Dr. Roberts is an authority on the fluid mechanics of outfall diffuser mixing and the development and application of mathematical models of wastewater fate and transport. He has extensive international experience in marine waste disposal including the design of ocean outfalls, review of schemes, numerical modeling, and oceanographic field work program design and data interpretation. His mathematical models and methods have been adopted by the U.S. EPA and are widely used. Dr. Roberts is a regular lecturer at the EPA Mixing Zone Workshops on the use of mathematical models and on outfall design for the Pan American Health Organization. He conducts research on diffuser mixing processes and has published extensively in this area. For this research he was awarded the Collingwood Prize of ASCE in 1980, and was UPS Foundation Visiting Professor at Stanford University in 1993-94. Dr. Roberts has lectured widely on outfall design around the world and is presently Co-Chairman of the Specialist Group on Marine Wastewater Disposal, International Association on Water Quality, London. He was also responsible for the physical modeling of dilution for the Boston Harbor tunneled outfall diffuser. This outfall, presently under construction, will be the worlds largest when completed in 1999.

JOAN ROSE
Department of Marine Sciences
University of South Florida

Dr. Rose is an international expert in water pollution microbiology. A full professor in the Department of Marine Sciences at the University of South Florida, her current research is focused on contamination of recreational marine waters and she is running a program called "Healthy Beaches" that utilizes molecular and pathogen monitoring techniques. Dr. Rose has authored or co-authored more than 120 manuscripts in environmental microbiology and has appeared on Dateline and Eye on America addressing water quality and waterborne disease issues. She is currently serving on the Water Science and Technology Board of the National Academy of Sciences and on two National Academy committees on "Climate and Health" and "Prioritization for Drinking Water Contaminants." Dr. Rose served as President of the Florida Environmental Health Association and as President of the Florida Branch of the American Society for Microbiology. She has been involved in the investigation of 8 waterborne outbreaks of Cryptosporidium in the U.S., United Kingdom and Canada, including the outbreak in Milwaukee where 400,000 people were ill and 100 individuals died.

DAVID B. ROSENBLATT
Atlantic Coastal Bureau
New Jersey Department of Environmental Protection

Mr. Rosenblatt assumed the position of Chief of the Atlantic Coastal Bureau in the DEP's new Division of Watershed Management in January 1999. Immediately prior, he had been in the DEP's Office of Enforcement Coordination (OEC) developing policy and standardizing enforcement procedures. In OEC he also developed and managed the DEP's small business compliance assistance program, Greenstart. He has designed and conducted coastal water quality studies and has managed New Jersey's coastal recreational beach program for twenty years. Mr. Rosenblatt also manages the Clean Shores Program, which uses state inmates to remove floatable debris from estuary shores to prevent beach closings. Mr. Rosenblatt has a B.S. in Environmental Science from Cook College of Rutgers University (1976) and an M.A. in Teaching from the College of New Jersey (1997). He is currently the co-chair of the Quality New Jersey Environmental Focus Group. Quality New Jersey is a joint business and government non-profit association to assist in the implementation of continuous improvement processes to enhance the State. He has been working with QNJ for 10 years.

STEPHEN B. WEISBERG
Executive Director
SCCWRP

Dr. Stephen Weisberg is Executive Director of the Southern California Coastal Water Research Project (SCCWRP) where he specializes in the design and implementation of environmental monitoring programs. He serves as chair of the Southern California Bight Regional Monitoring Steering Committee, which is responsible for developing integrated regional coastal monitoring for the Southern California Bight. He also serves on the Steering Committee for the US Global Ocean Observing System (GOOS) and on Technical Advisory Committees for the Santa Monica Bay Restoration Program, the University of Southern California Sea Grant Program, and the Southern California Wetlands Recovery Program. Dr. Weisberg received his undergraduate degree from the University of Michigan and his Ph.D. from the University of Delaware.

Published by the Sea Grant Program, Wrigley Institute for Environmental Studies, University of Southern California, Los Angeles, California. October 25, 2000. (USCSG-TR-01-2000)

Copies are available from:
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This publication has been produced with support from the National Sea Grant College Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under grant number NA 86 RG 0054, and by the California State Resources Agency. The views expressed herein do not necessarily reflect the views of NOAA or any of its sub-agencies. The U.S. Government is authorized to reproduce and distribute copies for governmental purposes.

The National Sea Grant Program is a network of 29 university-based programs in coastal and Great Lakes states involving more than 300 institutions nationwide in research, education and the transfer of technology regarding coastal, marine and Great Lakes issues. Sea Grant is supported by the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), in partnership with the states and private industry.