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Tracking Contaminants in Santa Monica Bay, Offshore of Greater Los Angeles

Santa Monica Bay is a major recreational and commercial resource for the Greater Los Angeles region. Industrialization and the dramatic increase of population in the region over the past 100 years have strained the bay's resources and polluted its sediments. To help evaluate any possible hazards posed by contamination, scientists from the U.S. Geological Survey (USGS) and local cooperating organizations are studying the processes that modify, transport, and redeposit sediments within Santa Monica Bay.

The Los Angeles metropolitan area is the second largest in the United States, with more than 10 million residents. Pollution that results from this urbanization is straining the resources of Santa Monica Bay, shown here. (Photo courtesy of Kevin Snavely, City of Los Angeles Bureau of Sanitation.)

Santa Monica Bay, offshore of Greater Los Angeles, provides crucial habitat for a rich web of marine life and supports important commercial and recreational fisheries. The bay and its beaches attract residents and visitors alike. More than 45 million people visit the bay's beaches each year, helping to support a regional tourism industry of $10 billion annually.

In the late 1980's, several sewage spills entered Santa Monica Bay, forcing popular beaches to be closed. These closures, along with concern over water quality, kept people away from beaches, even during unseasonably hot weather, resulting in serious economic losses for beachfront businesses. Much has since been done by the city of Los Angeles to reduce spills and improve overall sewage treatment, but water quality in the bay is still a concern.

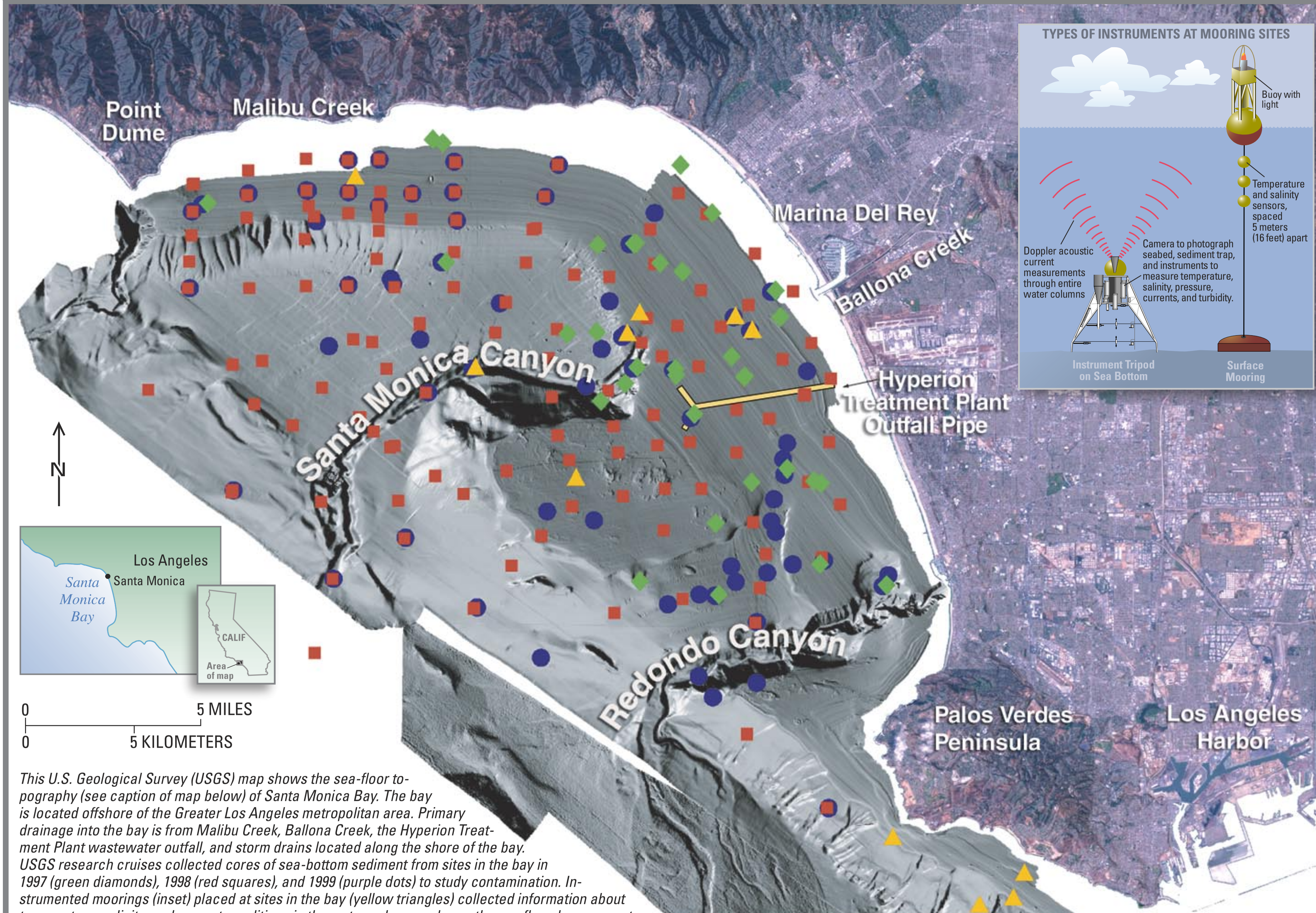
More than 10 million people now live in the Greater Los Angeles metropolitan area, a dramatic increase from 100,000 in 1900. Rapid population growth, industrialization, and their consequences, especially the increased need for waste disposal, have strained the resources of Santa Monica Bay. As the region grew, industrial, agricultural, and household contaminants increasingly flowed or were washed into the bay. Many of these pollutants are known to pose health hazards for people and for fish and other wildlife. Some of the contaminants of greatest concern are DDT (dichlorodiphenyltrichloroethane, a pesticide banned in the United States in 1972 because of its high toxicity to fish and reproductive hazard to birds), PCB's (polychlorinated biphenyls, toxic compounds widely used as insulation in electrical transformers until the 1970's), toxic metals (such as lead from industrial applications, fuel combustion, and tire and brake wear), and PAH's (polycyclic aromatic hydrocarbons, chemicals resulting from fuel combustion, oil spills, or natural oil seeps).

Much work has been done in Santa Monica Bay to monitor and determine the present distribution of contaminants. However, in order to effectively manage the bay in the future, it is important to also understand historical sources and sites of contamination and the processes that modify and redistribute contaminated sediments within the bay. To achieve this goal, the U.S. Geological Survey (USGS), in cooperation with the Southern California Coastal Water Research Project (SCCWRP) and the City of Los Angeles Bureau of Sanitation, is conducting a detailed study in Santa Monica Bay.

Part of this study has shown that discharge from creeks draining highly developed areas of Greater Los Angeles, such as Ballona Creek, is affecting water quality in Santa Monica Bay. Pesticides, fertilizers, oil and gas residue from automobiles, litter, and pet waste are washed off by rainwater, untreated, into storm drains and creeks that flow into the bay. Although the city of Los Angeles is increasingly diverting storm-water discharge to the region's Hyperion Treatment Plant, much untreated wastewater from storm drains still reaches the bay.

Because contaminants bind with sediment, historical contamination in Santa Monica Bay can be studied by taking cores of the upper few feet of sea-bottom sediment. Research cruises in 1997, 1998, and 1999 collected sediment cores in the bay. [continued on back page]

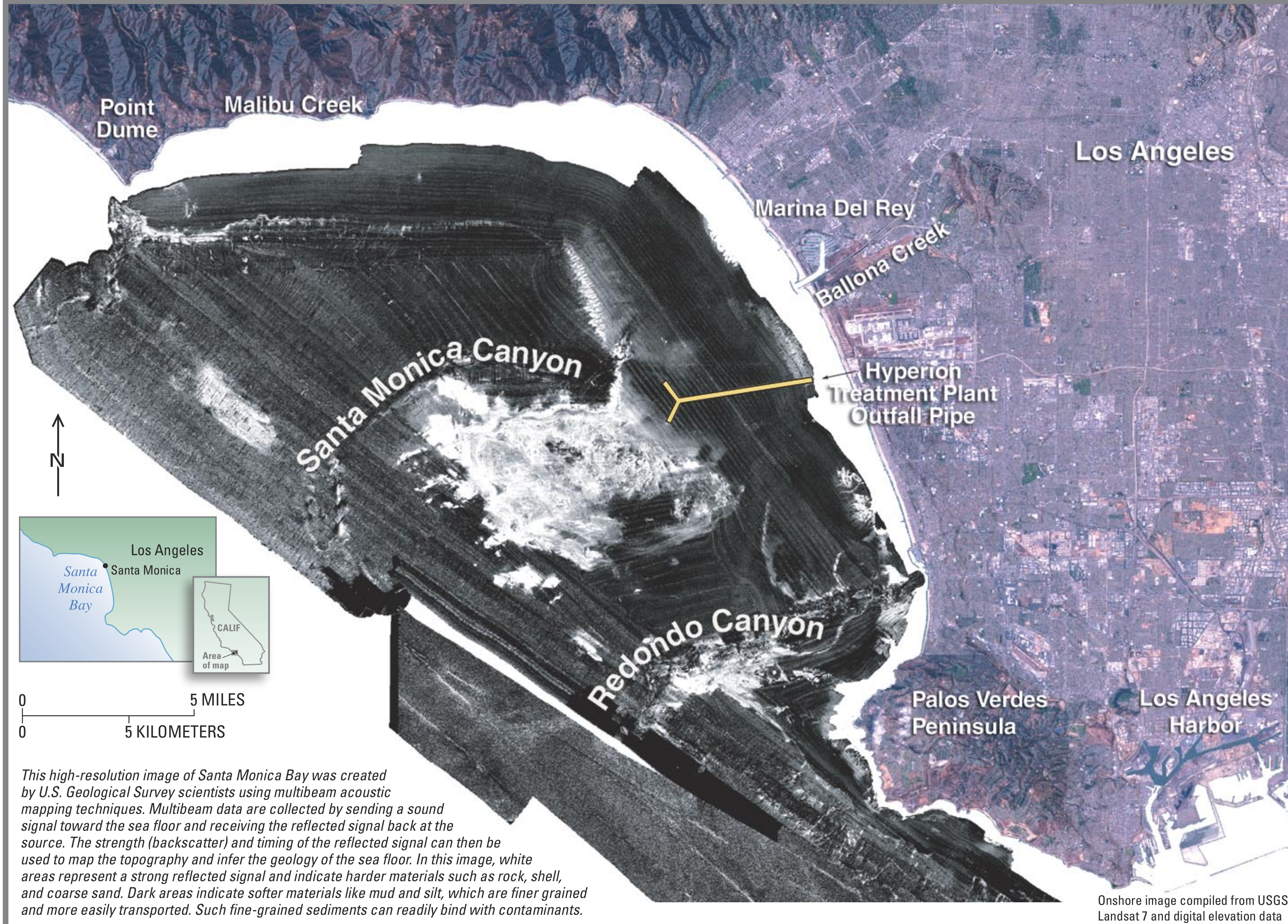
Shaded Relief Map of Santa Monica Bay



This U.S. Geological Survey (USGS) map shows the sea-floor topography (see caption of map below) of Santa Monica Bay. The bay is located offshore of the Greater Los Angeles metropolitan area. Primary drainage into the bay is from Malibu Creek, Ballona Creek, the Hyperion Treatment Plant wastewater outfall, and storm drains located along the shore of the bay. USGS research cruises collected cores of sea-bottom sediment from sites in the bay in 1997 (green diamonds), 1998 (red squares), and 1999 (purple dots) to study contamination. Instrumented moorings (inset) placed at sites in the bay (yellow triangles) collected information about temperature, salinity, and current conditions in the water column and near the sea floor, key parameters that are being used to study and model sediment and contaminant transport.

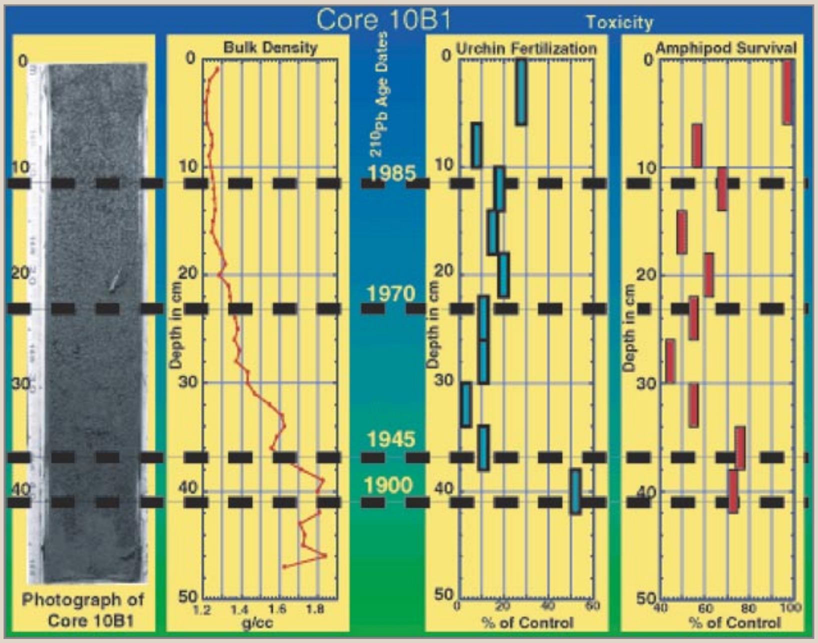
Onshore image compiled from USGS Landsat 7 and digital elevation data

Backscatter Map of Santa Monica Bay



This high-resolution image of Santa Monica Bay was created by U.S. Geological Survey scientists using multibeam acoustic mapping techniques. Multibeam data are collected by sending a sound signal toward the sea floor and receiving the reflected signal back at the source. The strength (backscatter) and timing of the reflected signal can then be used to map the topography and infer the geology of the sea floor. In this image, white areas represent a strong reflected signal and indicate harder materials such as rock, shell, and coarse sand. Dark areas indicate softer materials like mud and silt, which are finer grained and more easily transported. Such fine-grained sediments can readily bind with contaminants.

Reduced Contamination in Santa Monica Bay



This sea-bottom sediment core (left) was taken by the U.S. Geological Survey in 1997 near the Hyperion Treatment Plant outfall. Tests were conducted on samples from the upper 48 centimeters (19 inches) of the core, representing more than a century of deposition. Improved results for sea-urchin fertilization and amphipod survival, implying lower toxicity, are seen for samples younger than 1985, when efforts were made to improve sewage treatment and reduce pollution entering Santa Monica Bay. Upward decrease in the bulk density (here derived from gamma-ray "logging" of the core) is expected from natural compaction, but low density is also associated with the presence of sewage. The increase in bulk density at the top of the core probably represents reduced sewage contamination.

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Samples from the cores were dated using the radioactive isotope lead-210 (^{210}Pb), which is a naturally occurring product of the decay of radon gas and has a short half-life of 22 years. These dates were used to identify five key timelines within the cores:

1900—Before most development began in the Los Angeles region.
1945—When development was increasing in the region.
1970—When pollution of the bay is thought to have been severe.
1985—When sewage treatment was being improved following implementation of the Clean Water Act.
1997—When cores began to be collected.

Using this time framework, it was possible to analyze cores for historical changes in manmade contamination sources and types. This was done by examining:

Contaminants—Measurements were made of DDT, PCB's, toxic metals, PAH's, and other contaminants. Total organic carbon was measured as an indicator of sewage discharge.
Toxicity of samples—The toxicity of contaminants in samples of bottom sediment was estimated in the laboratory using sea-urchin fertilization tests and survival tests on amphipods (small crustaceans).
Foraminifera—The abundance and distribution of foraminifers (microscopic single-celled animals) in the cores were examined to provide information about the environment in which they lived. Changes or deformities in their tests (shells) were also noted as indicators of contamination.
Infaunal distributions —The distribution patterns of burrowing (infaunal) marine animals in the cores were examined to determine their relations to sediment toxicity results and the physical and chemical characteristics of the sediment.

To help determine the sources of contaminants found in the cores, as well as the processes that modify, transport, and redeposit sediments within Santa Monica Bay, scientists conducted additional studies that included:

Mineralogy—The mineral composition of samples from the cores was studied to provide information on the sources and transport pathways of sediments. This analysis was also important because some minerals, particularly the clay mineral smectite, adsorb contaminants.
Sedimentology—Sediment texture and grain size in the cores were examined to help determine the likely distributions of contaminants, as well as identify various habitats of bottom-dwelling marine organisms. Grain-size information also provided critical baseline data for developing sediment transport models. Additional studies were done to help reveal how sediment has accumulated and been deposited in Santa Monica Bay during the past 10,000 years.
Oceanography—Moorings placed in various locations in Santa Monica Bay in both El Niño and non-El Niño years collected information about temperature, salinity, and current conditions in the water column and near the sea floor, key parameters that influence sediment transport.

The ongoing efforts of the USGS and its cooperators in studying pollution in Santa Monica Bay show that contamination and sediment toxicity in the bay are being reduced by improvements in sewage treatment, especially the ending in 1987 of sewage sludge discharge from the Hyperion Sewage Treatment Plant. These studies also reveal that some chemicals, such as DDT, occur at depths associated with dates prior to their manufacture. Most likely, geologic events and storms, or more commonly, burrowing marine animals, have reworked the sediment to bury the contaminants deeper, which makes the contaminants less likely to enter the marine food chain. Sediment transport models are being developed from the new data provided by analysis of cores taken from the bay. Understanding the transport of sediment will be a critical tool for future management of Santa Monica Bay and its watershed.

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See also *Probing the Los Angeles Basin—Insights into Ground-Water Resources and Earthquake Hazards* (USGS Fact Sheet 086-02).

This Fact Sheet and any updates to it are available on-line at: http://geopubs.wr.usgs.gov/fact-sheet/fs155-02/