4 CONTAMINATED SEDIMENTS IN THE LOS ANGELES REGION

This section discusses the nature and extent of the contaminated sediment problem within the CSTF Study Area. Specific areas of concern are identified and estimated quantities of contaminated sediment that may need treatment and/or removal are provided. Lastly, sedimentation and water circulation patterns within the study area are also discussed as they relate to managing contaminated sediments.

4.1 Description of Contaminated Sediments

The specific criteria used to identify contaminated sediments in the Los Angeles region are not well defined. While agreement generally exists for the need to clean up the most severely contaminated sediments, consensus is not always available for more moderately contaminated sediments. Multiple national and regional sediment guidelines currently exist with respect to defining sediments as contaminated or not, and these guidelines in turn are mostly defined by concentrations of specific chemical contaminants (See Section 5).

Within the CSTF Study Area, contaminated sediments have generally been defined as those sediments which do not meet criteria for ocean or unconfined aquatic disposal and therefore are defined by multiple characteristics including sediment chemistry, toxicity, and bioaccumulative potential as outlined in regulatory guidance documents (the *Green Book* [EPA/USACE 1991] and the *ITM* [EPA/USACE 1998]). Ecological and/or human health risk assessment and other assessment tools (e.g., equilibrium partitioning, sediment guideline quotient methodologies, apparent effects threshold), while applied to specific sites in the region, generally have not been used to determine whether sediment are considered "contaminated", but instead have been used to address more specific questions regarding sediment characteristics.

Sediments with elevated levels of contaminants are often found near sources of anthropogenic inputs which can generally be categorized as either point or non-point sources. Point sources include discharges generated by a single process (e.g., manufacturing facility) and may be limited to a relatively small number of contaminants or a broad spectrum of contaminants (e.g., publicly owned treatment works). Non-point sources commonly integrate a variety of sources through a single pathway such as via flood control systems (e.g., the mouth of the Los Angeles River). Regardless of the source, contaminated sediments share some general characteristics due mostly to the physiochemical reactions that occur once contaminants enter an aqueous environment. This section describes contaminated sediments in the study area and summarizes the main environmental properties that impact the behavior of contaminants and/or contaminated sediments in the region.

4.1.1 Physical Characteristics of Contaminated Sediments

As discussed in Section 3, contaminants are often associated with areas of low water circulation, high sedimentation rates, and silt- and clay-dominated sediments. Two reversible processes dominate the behavior of contaminants in marine and estuarine systems: formation of metal colloids and binding of hydrophobic organic compounds onto fine sediment particles suspended in the water column. Due to the relatively large surface areas of fine-grained particles and environmental characteristics of areas where fine-grained particles settle out of the water column, contaminants are generally associated with silts and clays. A number of other factors impact the rate (and direction) of these physiochemical reactions, including redox potential (and interaction with sulfides), pH (and formation of metal hydroxides), amount and type of organic carbon, concentrations of iron (in the case of other metals), and the presence/activity of microbial organisms.

4.1.1.1 Grain Size

Due to the physiochemical processes described above, contaminants in sediments are usually associated with the fine-grained fraction and/or the interstitial pore water. While sequestration of contaminants can occur in high-clay sediments due to the lattice structure formed during clay mineralization, contaminants associated with silts are generally more susceptible to mobilization. Despite the affinity of contaminant binding to fine-grained sediments, grain size cannot always be used as an indication of contamination. For example, elevated metal concentrations due to boatyard sandblasting operations may be associated with relatively large paint chips. Locally, there are sites which are predominantly sand that frequently exhibit contamination (e.g. the Los Angeles River Estuary which typically has >75 percent sand [USACE 2002] and Ballona Creek Estuary which also typically has >75 percent sand [USACE 2003]). In both instances, contamination is most likely associated with the finer sediment fraction even though it represents only a small portion of the total volume.

4.1.1.2 Water content

The water content of contaminated sediments varies considerably depending on the grain size and compaction of the material. Recently settled surficial fines may be up to 70 percent water (as a percentage of the total mass). While, 'native' consolidated sediments may be as little as 20 percent water. In its review of available sediment data, the USACE found that percent water (moisture) of Los Angeles Basin sediments found unsuitable for open water disposal ranged from 21 to 41 percent and averaged 30 percent (USACE 2002).

4.1.1.3 Geotechnical Properties

Geotechnical characteristics of sediments are critical in the determination of whether they are suitable for reuse at construction and/or fill sites. Final site design and land use typically defines the minimum geotechnical qualities of the fill material. Within the study area, fine-grained sediments have been used as construction fill by either placing it selectively within a fill area (e.g., Pier T fill at the Port of Long Beach), diverting it to an alternative project component with less stringent design criteria (e.g., creation of Port of Los Angeles' Shallow Water Habitat with fine-grained sediments dredged for the Pier 400 project), or by placing it in alternating lifts between layers of coarser-grained material to meet project specifications (USACE 2002).

4.1.1.4 Variability by Location

Within the CSTF Study Area, a diverse array of land uses contributes a variety of contaminants to the environment and physical characteristics are likewise the result of a variety of input parameters. Physical characteristics in the context of regional sediment contamination issues are a reflection of current, recent, and historical discharges. The degree of sediment contamination is often highly correlated with proximity to anthropogenic sources at various spatial scales, and the physiochemical characteristics of sediments such as grain size distribution, organic carbon content, and iron content likewise vary at many spatial scales. A limited amount of data has been compiled for the study area and is presented in Table 4-1 to illustrate the variability in some commonly measured physical characteristics.

Physical characteristics interact with chemical constituents to produce highly variable systems in terms of the degree of contaminant sequestration, availability of contaminants to biological systems, and mobility of contaminants between bound and aqueous forms.

4.1.2 Locations of Contaminated Sediments

As part of the Bay Protection Toxic Cleanup Program (BPTCP), the Los Angeles RWQCB prioritized contaminated sites to protect water and sediments from discharges of waste, in-place sediment pollution and contamination, and any other factors that impacted beneficial uses of water resources. After considering available data, sites that demonstrated considerable impairment were designated as either high priority hot spots or sites of concern if they met specified criteria (LARWQCB 1997). SWRCB designated toxic hot spots and the sites of concern are presented in Figure 4-1.

4.1.2.1 Hot Spots

The Los Angeles RWQCB prioritized a number of sites within their jurisdiction for remediation or prevention of toxic hot spots. Within the CSTF Study Area, three sites were designated high priority toxic hot spots: Santa Monica Bay/Palos Verdes Shelf, Los Angeles Outer Harbor/Cabrillo Pier, and Los Angeles Inner Harbor/Dominguez Channel/Consolidated Slip.

Table 4-1
Comparison of Total Organic Carbon, Percent Solids, and Percent Sand in Various Locations within the Study Area.

Location	Study/Data Source/Sampling Methodology	Percent TOC	Percent Solids	Percent Sand & Gravel
Marina del Rey	Marina Del Rey (BPTCP, surface grab)	1.1	31.4	7
Marina del Rey	Marina Del Rey (CSTF Cement Stabilization Pilot Study)	NA	NA	93
Ballona Creek	Ballona Creek (USACE Feasibility Study, composite)	NA	NA	77
Ballona Creek	Ballona Creek (BPTCP, surface grab)	3.0	51.5	35
Coastal Shelf	Palos Verdes Shelf (BPTCP, surface grab)	1.5	56.3	41
Port of Long Beach Inner Harbor	Pier S Realignment (average of top composites, N=2)	0.2	68.7	52
Port of Long Beach Inner Harbor	Pier S Realignment (average of bottom composites, N=2)	0.1	73.7	48
Port of Long Beach Inner Harbor	Channel Two (average of Area F top composites, N=8)	1.4	62.7	29
Port of Long Beach Inner Harbor	Channel Two (average of Area F bottom composites, N=8)	0.5	74.0	46
Port of Long Beach Middle Harbor	Main Channel (average of top composites, N=3)	0.2	71.2	55
Port of Long Beach Middle Harbor	Main Channel (average of bottom composites, N=3)	0.1	78.6	54
Port of Long Beach Outer Harbor	Long Beach Outer Harbor (BPTCP, surface grab)	0.9	52.1	30
Port of Long Beach Outer Harbor	Long Beach Channel (BPTCP, surface grab)	1.2	52	19
Port of Los Angeles Inner Harbor	Berths 121-124 (average of top composites, N=2)	0.1	76.9	63
Port of Los Angeles Inner Harbor	Berths 121-124 (average of bottom composites, N=2)	0.0	80.6	73
Port of Los Angeles Inner Harbor	Consolidated Slip (range, multiple sampling techniques)	0.1 - 10.4	33 - 81	5 - 98
Port of Los Angeles Inner Harbor	Southeast Basin (BPTCP, surface grab)	2.2	52.8	17
Port of Los Angeles Inner Harbor	Consolidated Slip (BPTCP, surface grab)	4.4	36.5	13
Port of Los Angeles Inner Harbor	Southwest Slip (BPTCP, surface grab)	1.7	53.3	26
Port of Los Angeles Outer Harbor	Off Cabrillo Beach (BPTCP, surface grab)	2.2	50.2	14
Los Angeles River Estuary	CSTF Pilot Studies	0.4	56.4	78

NA – data not available

Sources: AMEC 2001a, AMEC 2001b, AMEC 2002, Anderson et al. 1998, MEC Analytical Systems 1999, Ogden 2000, USACE/County of Los Angeles 1998, and USACE 2002

The Palos Verdes Shelf has been identified as an impaired water body due to sediment contamination (DDT, PCBs, cadmium, copper, lead, mercury, nickel, zinc, PAHs, and chlordane), sediment toxicity, tissue bioaccumulation of pollutants (DDT, PCBs, silver, chromium, and lead), and the issuance by the California Department of Fish and Game of a health advisory warning against consumption of white croaker (*Genyonemus lineatus*). Elevated DDT and PCB levels have been the focus of much attention by a variety of regulatory authorities, among them the USEPA, which is developing a plan for remediation of the area. Although heavy metals contamination is recognized as an additional source of impairment, remediation of the DDT impairment may fully or partially address the issue.

The area in the vicinity of the Cabrillo Pier in the Outer Los Angles Harbor is considered impaired due to sediment contamination (PAHs, DDT, zinc, copper, and chromium), sediment toxicity, and tissue bioaccumulation of DDT. High bacteria levels are also a concern. As part of the Main Channel Deepening Project, the USACE and the Port of Los Angeles are currently in the process of expanding the Cabrillo Shallow Water Habitat area to cover much of the area with available uncontaminated sediments, effectively capping a portion of the area. Additional efforts are being undertaken by the Port of Los Angeles to address sources of impairment other than the existing sediments.

In the Inner Los Angeles Harbor, Consolidated Slip and the Dominguez Channel Watershed are recognized to be impaired: sediment contamination (PAHs, zinc, chromium, lead, DDT, chlordane, and PCBs), sediment toxicity, benthic community effects, and tissue bioaccumulation (DDT, chlordane, PCBs, organotins, and zinc) have been documented; a fish consumption advisory has also been posted. The Consolidated Slip Restoration Program Working Group is currently considering remediation alternatives under the leadership of the LA RWQCB. The group has recently compiled data showing the extent of contamination to be at least 20 ft below the harbor bottom in some areas and is considering available restoration alternatives for sediments as well as the Dominguez Channel Watershed, which is recognized to be a potential source of recontamination.

4.1.2.2 Areas of Concern

The BPTCP process also included listing a number of sites as areas of concern. These sites were candidates for listing as toxic hot spots due to substantial impairments, but ultimately were not among those sites prioritized for more immediate attention. Sites listed within the CSTF Study Area (and the respective reasons for listing) include Marina del Rey (sediment chemistry, mussel bioaccumulation), Cerritos Channel in the Port of Long Beach (mussel bioaccumulation), the Los Angeles River Estuary (sediment chemistry, mussel and fish bioaccumulation), Ballona Creek Tidal Prism (sediment chemistry and stormwater impacts), Offshore Santa Monica Bay (sediment chemistry and fish bioaccumulation), Venice Canals in the City of Los Angeles (mussel bioaccumulation), Colorado Lagoon in the City of Long Beach (sediment chemistry, mussel and fish bioaccumulation), Long Beach Marina (sediment chemistry), and Shoreline Marina in the City of Long Beach (sediment chemistry).

4.1.3 Amounts of Contaminated Sediments

4.1.3.1 Historical Volumes of Contaminated Sediments

Historical volumes of contaminated sediment dredged from the Los Angeles Region include approximately 3.2 million cy from maintenance dredging at the Los Angeles River Estuary and Marina del Rey from 1980 through 2001, and 2.0 million cy from capital improvement dredging at Pier T in 1999. A majority of the contaminated sediment was used as harbor infill by the Port of Long Beach, with the balance disposed of at various harbor locations including the Port of Long Beach Borrow Pit, Port of Los Angeles Shallow Water Habitat, Pier 300, and the Energy Island Borrow Pit (USACE, 2003a). Table 4-2 summarizes the quantity of contaminated sediment dredged from different areas within the Los Angeles Region between 1980 and 2001 and the disposal locations of the dredged material.

Table 4-2
Historical Dredging of Contaminated Sediment Quantities in the LA Region

Year	Volume (cy)	Dredged Location	Disposal Location	Comment
1980	1,945,646	LARE	POLA Pier 300 Fill	Maintenance
1991	122,238	LARE	POLB Pier J Fill	Maintenance
1995	300,960	LARE	POLB Borrow Pit	Maintenance
1995	132,000	Marina del Rey	POLA-SWH	Maintenance
1997	62,426	LARE	POLB Borrow Pit	Maintenance
1999	122,070	LARE	POLB Pier E Fill	Maintenance
1999	391,731	Marina del Rey	POLB Pier E Fill	Maintenance
1999	1,508,000	POLB Pier T	POLB Pier E Fill	Capital Improvement
1999	450,000	POLB Pier T	POLB Infill	Capital Improvement
2001	135,171	LARE	NEIBP	Maintenance

LARE – Los Angeles River Estuary
NEIBP –North Energy Island Borrow Pit, Long Beach
POLB - Port of Long Beach
POLA - Port of Los Angeles
SWH – Shallow Water Habitat

4.1.3.2 Potential Future Volumes of Contaminated Sediment

The USACE anticipates continuing its regular maintenance dredging programs at the Los Angeles River Estuary and Marina del Rey entrance channels. The projected volumes of contaminated sediment to be dredged at Los Angeles River Estuary and Marina del Rey for the next 20 years are 1.5 and 1.0 million cy, respectively. The USACE is currently conducting a feasibility study to evaluate several sediment control alternatives at Marina del Rey and along Ballona Creek to reduce sediment depositions at the harbor entrance and hence reduce the need for future maintenance dredging. However, before the implementation of a sediment control alternative at Marina del Rey, it is projected that the Los Angeles River Estuary and Marina del Rey combined will yield 2.5 million cy of contaminated sediment in the next 20 years due to regular maintenance dredging. This value is less than during the previous 20 years because at least one of the past dredging events for the Los Angeles River included a significant over-dredge amount, not normally included in the maintenance removal process.

Several capital improvement projects have been proposed for Ports of Los Angeles and Long Beach for the next 20 years. Project locations include the entrance channel and wharves in the Los Angeles Harbor; redevelopment of Piers E, F G, S, and T; the Naval Complex Liquid Bulk Terminal; Channel 2; the Harbor Pilots' Turning Basin; Carnival Cruise Terminal; and West Basin Installation Restoration cleanup site in Long Beach Harbor. These proposed projects combined are expected to generate an estimated total of approximately 16.3 million cy of dredged material, of which an estimated total of approximately 5.7 million cy (35 percent) is expected to be contaminated and unsuitable for ocean disposal (USACE 2003).

Adding the maintenance dredging by USACE to the projected dredging required for capital improvement projects for the Ports of Los Angeles and Long Beach, the projected contaminated sediments to be dredged in Los Angles County for the next 20 years is approximately 8.3 million cy. In addition, remedial action is also being contemplated for Consolidated Slip at the Port of Los Angeles. While sediment characterization in the Consolidated Slip is still underway, preliminary estimates indicate that at least 1 million cy of sediments are contaminated, not including the Dominguez Channel.

4.1.4 Characterization of Contaminants

As stated above, the varied land use history of the Los Angeles Basin has resulted in sediments within the CSTF Study Area exhibiting a variety of contamination types. Generalizations within the study area are twofold and include: 1) the propensity of sediments at the mouths of flood control structures to contain elevated levels of metals (especially lead and zinc), pesticides (e.g., DDT), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and total recoverable petroleum hydrocarbons (TRPH) and 2) for sediments in the northern portion of San Pedro Bay to exhibit elevated levels of the pesticide DDT due to releases into the sanitary sewer system (and subsequently the Palos Verdes Shelf) and into the Dominguez Watershed (and subsequently the Ports of Los Angeles and Long Beach) from the Montrose

Chemical Corporation facility in Torrance. NOTE: Additional information re: regional sediment contaminants may be compiled when the CSTF database is incorporated into the strategy report and could be presented here, possibly with SCCWRP/BPTCP data (Section 5 scheduled for draft completion 31 November 2003).

4.1.5 Biological Community Effects of Contaminated Sediments

As discussed in Section 3, contaminated sediments impact biological communities on many levels. Direct toxicity as a result of ingestion, dermal contact, exposure to pore water, etc. is one of the most severe consequences of sediment contamination, but is not well documented *in situ*. The effects of toxicity and other impacts from sediment contamination are indicated by benthic community studies, which have documented low infauna abundance and diversity in naturally occurring communities from areas with relatively elevated sediment contaminant levels (e.g. MEC 2003). Bioaccumulation of contaminants within tissues and subsequent potential biomagnification within the food chain are also significant concerns when considering impacts of elevated contaminant levels in sediments. Exposure of marine and estuarine organisms to contaminants also have the potential to lead to human exposure; due to elevated fish tissue contaminant levels, the California Office of Human Health Hazard Assessment has issued consumption advisories for the following species in portions of the CSTF Study Area: white croaker, queenfish, surfperches, corbina, black croaker, sculpin, rockfishes, and kelp bass (CFG 2003). Areas for which fish consumption advisories have been issued are presented in Figure 4-1.

4.2 Sources of Contaminants

Due to the intensely urbanized environment surrounding the CSTF Study Area, sources of sediment contamination are varied. The following sections summarize characteristic sources of contaminants for two environments likely to exhibit elevated chemical concentrations within their sediments: ports and marinas, and watersheds.

4.2.1 Ports and Marinas

4.2.1.1 Historical Sources

Ports and marinas share some aspects that contribute to elevated concentrations of contaminants in sediments while others aspects are specific to each. The Ports of Los

Angeles and Long Beach have a history of a variety of land uses relating to the transfer of fishery resources, bulk liquid and solid cargo, and passengers between land and vessels. The ports have been designed to facilitate these transfers, and commensurate development of shoreline infrastructure to support fueling, cargo and passenger transfer from vessel to overland transport, and shipbuilding/ship repair has been developed over the past century. Release of contaminants over the past century due to a combination of accidental release, ignorant pollution (especially prior to approximately 1960), and intentional discharges, combined with the scale of the ports' operations, has resulted in the accumulation of contaminants in harbor sediments. Large areas within the ports historically impacted by these releases have been dredged over the past 20 years due to channel and berth development projects and shoreline construction activities.

Marinas in the CSTF Study Area have had a much more limited use compared to the two main ports. Historically, sediment contamination in marinas can be attributed to releases from commercial and private vessels, their proximity to points of stormwater discharge, and low circulation environments. Operationally, the marinas contribute to sediment contamination through the actions of a minority of boaters whose poor "housekeeping practices" result in the release of contaminants such as fuel, lubricating oils, bilge water, and debris. Boat anti-fouling paints also contribute contaminants (especially organotins and heavy metals) to the environment via leaching (Schiff et al. 2003) and from the release of sanding dust. Specific sites within marinas, such as boatyards or fuel docks, may contribute pollutants at a disproportionate rate and may function as point sources of specific contaminants.

Historical releases of contaminants into the environment in some cases result in ongoing impacts well beyond the time of discharge due to the persistence of organic chemicals such as organochlorine pesticides and PCBs. Likewise, heavy metals generally are stable when incorporated in sediments, and remain a potential ongoing source in the event of sediment mobilization.

4.2.1.2 Current Sources

Historical sources of contaminants in ports and marinas have for the most part been addressed through the National Pollutant Discharge Elimination System (NPDES) permitting process. This process seeks to eliminate discharges to water bodies above thresholds demonstrated to be detrimental to the environment. Current ongoing sources of elevated contamination are dominated by impacts from stormwater discharges into the ports and marinas and dispersion of existing contaminants via various sediment transport mechanisms (e.g., bioturbation, circulation-driven processes, etc.).

4.2.2 Study Area Watersheds

4.2.2.1 Historical Sources

Discharges to the estuarine and marine environments via stormwater pathways contribute a variety of contaminants to sediments within the CSTF Study Area. Stormwater discharge into the coastal environment is probably the single most important historical (and ongoing) process impacting the sediment quality within the study area. Major stormwater discharge areas within the study area include Malibu Creek, Ballona Creek, Dominguez Creek, the Los Angeles River, and the San Gabriel River.

The primary historical contaminant point source important on a regional basis is the discharge of treated municipal wastewater offshore onto the Palos Verdes Shelf and into Santa Monica Bay. Discharge from the Los Angeles County Sanitation Districts' ocean outfalls has resulted in a 17-acre area of sediments contaminated with 100 metric tons of DDTs and 10 metric tons of PCBs. The discharge of wastewater and sludge (now terminated) from the City of Los Angeles has resulted in areas of sediment contamination and biological impact within Santa Monica Bay.

4.2.2.2 Current Sources

Current sources of pollutants which contribute to contaminated sediments are numerous, diverse, and enter the system primarily via the stormwater system. The climate of the study area, with only limited rainfall in the winter, results in a first flush of contaminants with the first winter storm that commonly integrates watershed contaminant loading of the previous 9 months. Subsequent stormwater flows do not attain the contaminant load associated with the first storm, but significant contaminants are commonly part of the subsequent flows due to the geographical heterogeneity of rainfall and contaminant sources (e.g., Schiff and Sutula 2001, Tiefenthaler et al. 2001a and 2001b).

Although NPDES permits have long been used to regulate discharges from individual facilities, the process has only recently been adopted for municipal stormwater discharges. It is not known at this time what patterns will emerge from the additional data being collected under these permits or how specific best management practices (BMPs) will be implemented to reduce or eliminate impacts to downstream environments.

4.3 Circulation and Sediment Transport in the Study Area

Circulation patterns within the study area govern the observed deposition and transport of the contaminated sediments within the study area. Understanding of the existing circulation patterns and sediment transport characteristics are important for the evaluation of some of the management options described in Section 6 such as the selection of shallow water habitat areas, confined disposal areas, as well as capping sites.

The oceanic circulation system of the Southern California Bight, in which the CSTF Study Area is located, is typically driven by the California Current in the spring and the California Undercurrent in the fall and winter (CLAEMD 1992). Within Santa Monica Bay, water has been found to move both up-coast and down-coast, indicating the presence of a gyre (vortex) in the bay (CLAEMD 1992). Within the northern portion of San Pedro Bay, the effects of the Federal Breakwater dominate circulation patterns.

Contaminated sediments in the CSTF Study Area are primarily located in unexposed portions of bays and estuaries, and effects of oceanic currents and waves on exposed beaches are not included in this discussion. This section will focus on areas within the study area likely to be impacted by contaminated sediments and is therefore limited to the vicinity of Marina del Rey/Ballona Creek Mouth and areas inside the Federal Breakwater in the northern portion of San Pedro Bay.

4.3.1 Marina del Rey/Ballona Creek Mouth

Marina del Rey Harbor is located in Santa Monica Bay along the Southern California coastline. The harbor entrance and the Ballona Creek outlet are comprised of four major structures. The North and Middle Jetties define the main harbor channel. Ballona Creek discharges into Santa Monica Bay through the channel between the Middle and South Jetties. A detached breakwater just offshore reduces wave exposure of the Marina del Rey Harbor, providing safe navigation conditions within the harbor entrance channels and interior portions of the marina.

Nearshore currents at the Marina del Rey entrance are the combination of tidal and sub-tidal currents, as well as the wind/wave-induced longshore currents. Typical mean monthly sub-tidal currents in Santa Monica Bay are small, in the order of 5 cm/s (USACE 1995). Wind effect is appreciable on the short-time circulation fluctuations of water velocity in the bay, producing a mean 5-to-10 day sub-tidal current of about 20 cm/s (USACE 1995).

During flood tide, the flood current enters Marina del Rey Harbor through the north and south harbor entrances, as well as into Ballona Creek. The flood flow is slightly stronger on the north side and relatively weaker on the south side. During ebb tide, the flow from Ballona Creek hits the breakwater and splits into two parts. The main part flows into the ocean through the south entrance, while the other part flows along the detached breakwater to the northwest and leaves the north harbor entrance. In general, tidal currents at the Marina del Rey Harbor entrance are small. Field data collected by USACE during their dredging operation in 1994 indicated that nearshore currents near the south harbor entrance and the Ballona Creek mouth were in the range of 2 to 16 cm/s. A recent numerical model study conducted by USACE (2003) also indicated that tidal currents in the vicinity of the south harbor entrance and the Ballona Creek mouth are in general less than 5 cm/s.

Tidal and sub-tidal currents near the south entrance and Ballona Creek mouth are generally too small to re-suspend the sediments being discharged from Ballona Creek and deposited behind the breakwater. Sediments near the Ballona Creek mouth will be resuspended and transported only during wave and rainstorm events. A recent study by USACE (2003) indicated that sediments deposited near the mouth of Ballona Creek will start to migrate southward under a 5-year storm wave event, or northward under an 8-year storm wave event. In addition, the study also concluded that the sediments will be resuspended and transported southward into the bay under a 1-year or larger flood event.

4.3.2 Ports of Los Angeles and Long Beach, and the Los Angeles River

The Ports of Los Angeles and Long Beach occupy the entire western half of San Pedro Bay and form the nation's largest harbor complex. The ports are protected from incoming waves by the Federal Breakwater, which consists of three individual rock jetty structures. In addition to protecting the ports from waves, the Federal Breakwater reduces the exchange of the water between the harbor and the rest of San Pedro Bay, hence creating unique tidal circulation patterns.

In the last three decades, the ports have undertaken a long-range effort, known as the 20/20 Plan, to increase the capacity of the ports. For the Port of Los Angeles, the 20/20 Plan included the construction of the Pier 400 and related channel deepening projects. The Pier 400 causeway essentially divided the outer harbors into two halves, with the Port of Long Beach to the east and the Port of Los Angeles to the west. Water exchange between the east and west sides of the causeway is maintained through a 300-foot opening adjacent to the Navy Mole. The opening is known as the Transportation Corridor Gap or the "causeway gap" in the literature.

Maximum flood and ebb current patterns in the Ports of Los Angeles and Long Beach under typical tidal conditions are shown in Figures 4-2 and 4-3, respectively. The tidal currents shown in the figures were predicted by a depth-averaged two-dimensional hydrodynamic model RMA2 developed by the US Army Corps of Engineers. The model has been calibrated against field data collected by NOAA at the Port of Long Beach, as well as against more sophisticated three-dimensional model. Details about the model capability, setup and calibration can be found in Everest (2001).

As shown in Figure 4-2, flood currents entering the Los Angeles Harbor through Angel's Gate are blocked by Pier 400 and forced to go around the structure and conform to the shape of the Pier 400 Landfill. On the Long Beach side, flood currents enter the harbor through the Queen's Gate as well as the opening near the eastern tip of the Federal Breakwater. Flood currents passing through Queen's Gate flow to either side of Pier J.

During the ebb tide, as shown in Figure 4-3, the flow in the harbor is drawn from all directions as a potential flow toward the exits. Ebb currents leaving the Los Angeles Harbor flow mainly through the Angles Gate. On the Long Beach side, ebb currents exit either through the Queen's Gate or the eastern opening passing the tip of the Federal Breakwater. An important observation about the tidal flow patterns is that ebb flows from the Los Angeles River Estuary will exit the breakwater either through the eastern opening or the Queen's Gate without entering the Los Angeles Harbor, indicating that contaminants discharging from the Los Angeles River Estuary during dry weather flow are unlikely to be transported into the Los Angeles Harbor.

Tidal currents within the Ports of Los Angeles and Long Beach are generally very small. As shown in Figures 4-2 and 4-3, typical maximum tidal currents within the harbor are in general less than 0.5 ft/s. Tidal currents entering and exiting Angel's Gate and Queen's Gate are higher, but are still in general less than 0.8 ft/s. These small tidal currents generally will not cause sediment resuspension and sediment transport within the harbor. Resuspension and transport of sediments will occur during major rain or wave storm events. As an example, Figure 4-4 shows the flow patterns in the Ports of Los Angeles and Long Beach with a 133-year flood discharging from the Los Angeles River Estuary into the harbor. Under such a flood event, currents near the Los Angeles River Estuary can be as high as 15 to 20 ft/s, causing resuspension and transport of deposited sediments near the river entrance into the Ports of Los Angeles and Long Beach.

Field measurement or model predicted storm discharges from Dominguez Channel is unavailable. Nevertheless, it is expected that storm discharge from Dominguez Channel will produce currents high enough that can cause resuspension and transport of deposited sediments in the Ports of Los Angles and Long Beach.

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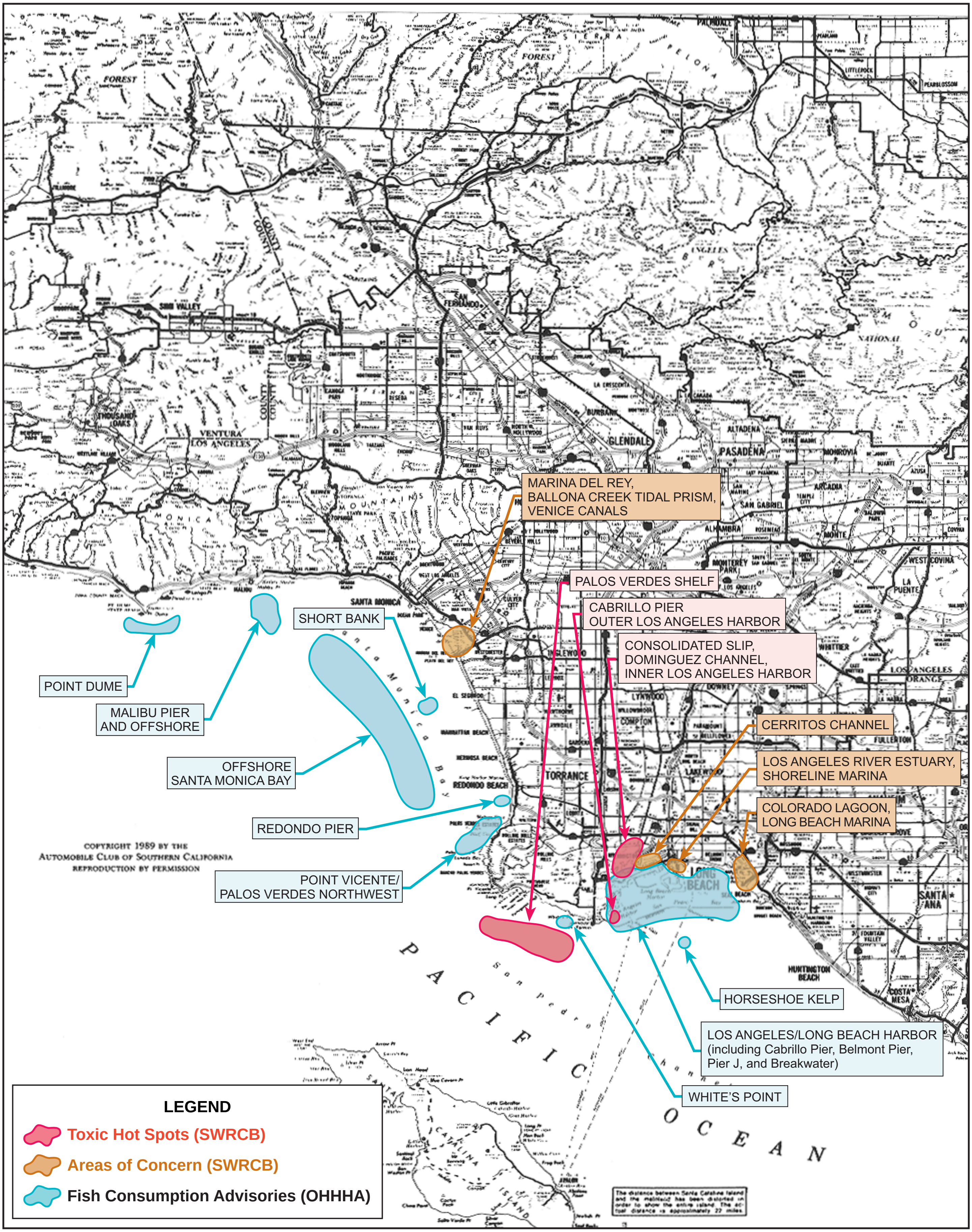

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Figure 4-1
Coastal Areas Identified by the State of California as Exhibiting Impairment(s) Related to Sediment Contamination within the CSTF Study Area

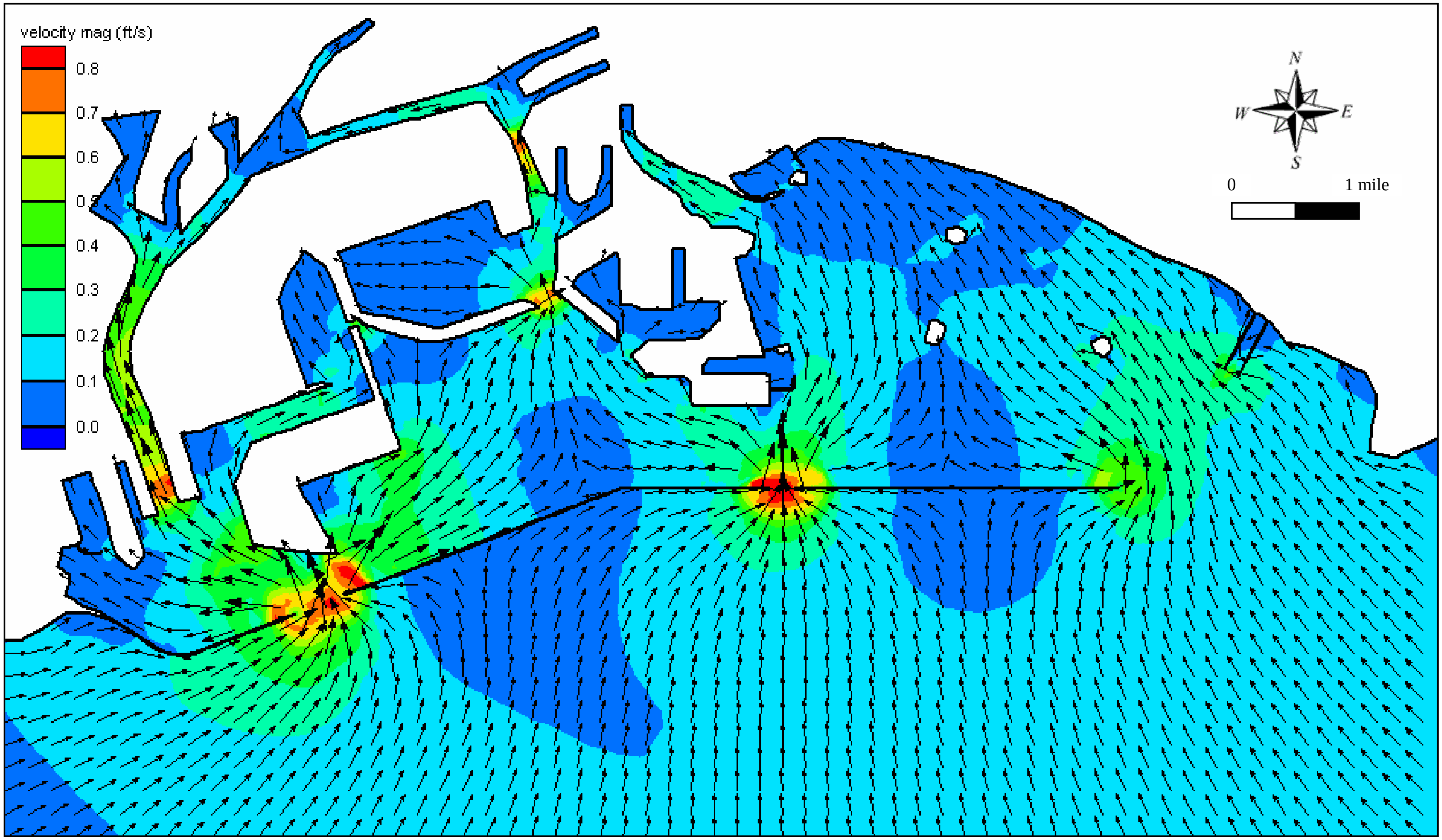

Figure 4-2 Maximum Flood Current during Typical Tide Condition

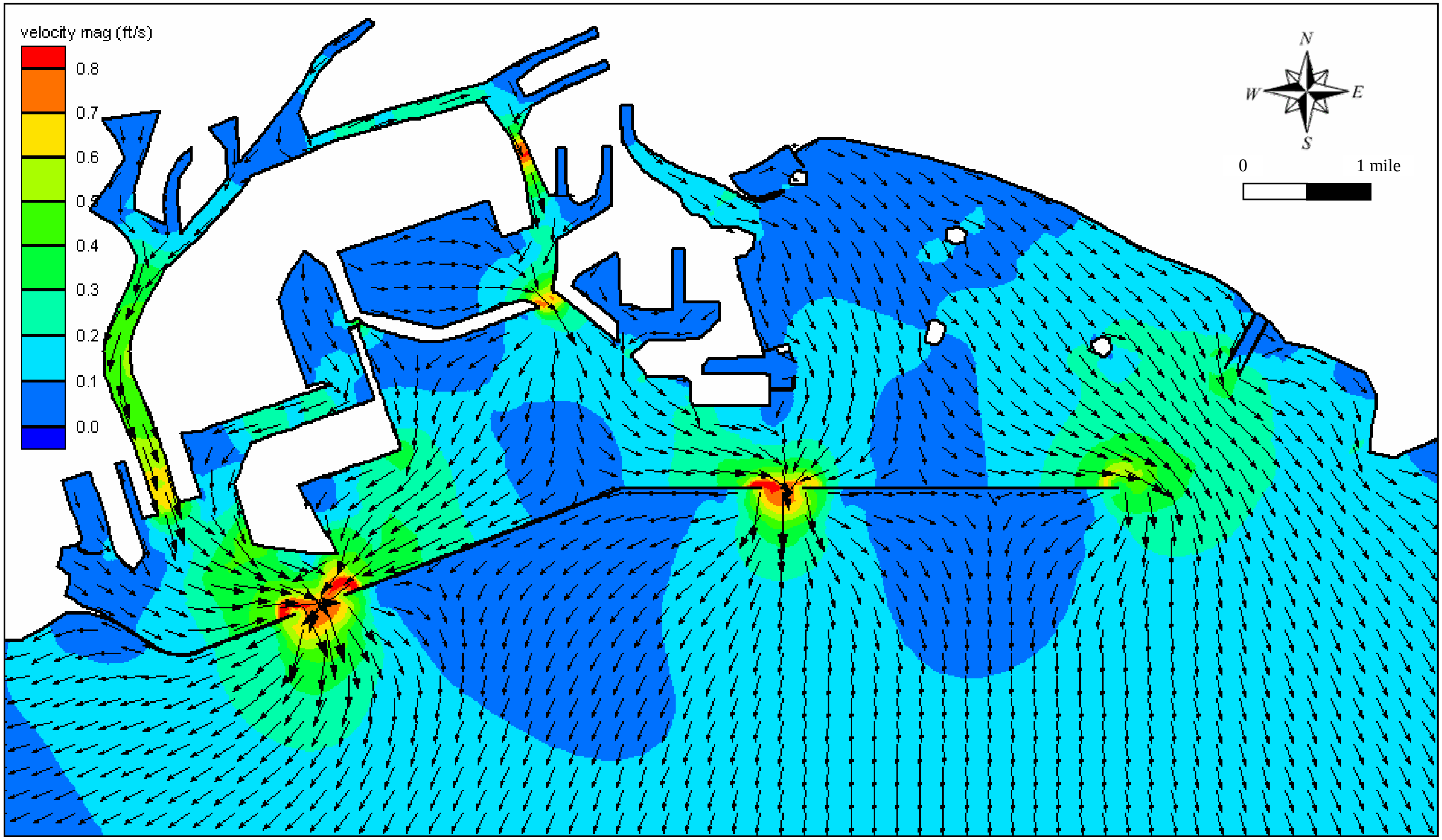

Figure 4-3 Maximum Ebb Current during Typical Tide Condition

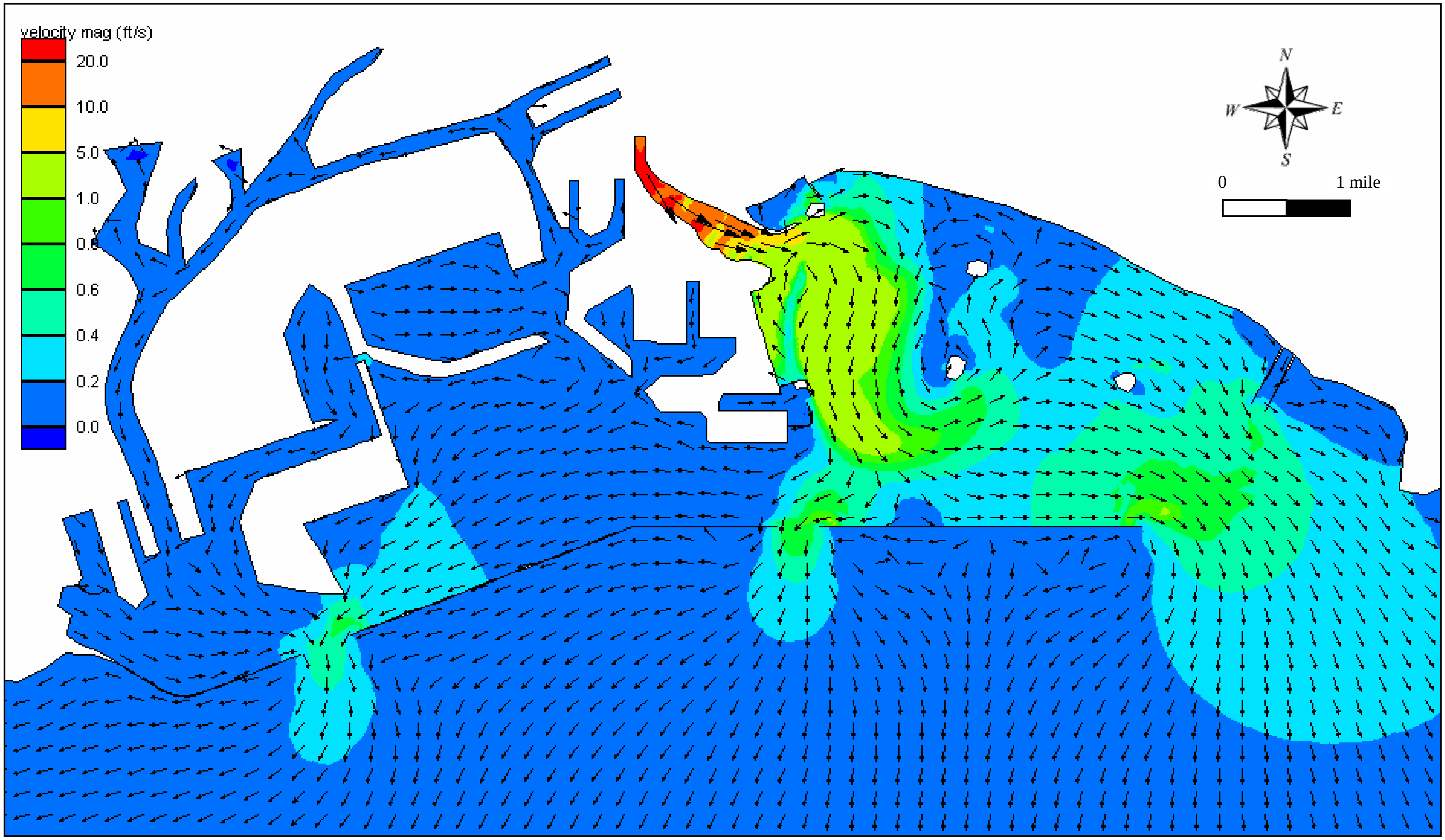

Figure 4-4 Maximum Current during a 133-year Storm Discharge from Los Angeles River