Appendix F

Compilation of Sediment, Storm Water, and Water Quality Data Summaries for the Mouths of Paleta, Chollas, and Switzer Creeks

Sediment, storm water, and water quality data collected from the mouths of Paleta, Chollas, and Switzer creeks were analyzed to provide guidance for the source assessment. The pollutants analyzed include PCBs, PAHs, and chlordane. A compilation of the data available for the creek mouths are presented in the following sections. It should be noted that much of the data have already been presented and analyzed in previous studies. Data reported as part of permit monitoring requirements are also included. This section summarizes those past studies. For more detail, see the original reports cited in this appendix.

F1. Sediment Quality Data

This section summarizes the data for Paleta, Chollas, and Switzer creeks for the pollutants addressed in this TMDL. The summary includes data considered by the San Diego Water Board and U.S. EPA in developing the 1998 and 2002 section 303(d) lists as well as subsequent data.

F1.1 Summary of Bay Protection and Toxic Cleanup Program (BPTCP) Data

Sediment quality in San Diego Bay was investigated as part of a cooperative statewide monitoring effort to assess the degree of chemical contamination and associated biological effects in California's Bays and Estuaries. As a part of the Bay Protection and Toxic Cleanup Program (BPTCP), chemical and biological data were collected between October 1992 and May 1994, and again in December 1996 for Switzer Creek (Fairey et al. 1996; Fairey et al. 1998). These data were used as the basis for the section 303(d) listings of the San Diego Bay shorelines near the mouths of Paleta, Chollas, and Switzer creeks.

BPTCP data for San Diego Bay were used to assess areas of potential concern in the Bay. Sediment samples from three stations were collected and analyzed in the area of the Paleta Creek channel. Sediment samples from six stations were collected and analyzed in the area of the Chollas Creek channel and sediment samples from two stations were collected and analyzed in the area of the mouth of Switzer Creek. The data generated by the BPTCP program resulted in the areas near the mouths of Paleta Creek, Chollas Creek, and Switzer Creek to be listed as toxic hotspots. The data also resulted in the mouths of Paleta, Chollas, and Switzer creeks to be included on the 1998 and 2002 section 303(d) Lists of Water Quality Limited Segments as a priority for establishing a TMDL that addresses benthic community degradation and toxicity in the marine sediment.

The study focused on sediment chemistry, benthic community analysis, and toxicity testing of sediments and sediment pore water. Sediment chemistry results were compared to ERM guidelines developed by NOAA. Total chlordane, total PCBs and total PAHs were found to exceed ERM values at San Diego Bay stations. An ERM summary quotient (ERMQ) > 0.85 was the indicator used to classify station sediment chemistry as elevated. Results from the BPTCP stations sampled near the mouths of Paleta, Chollas, and Switzer creeks are listed in Tables F-1 through F-6.

Toxicity test results were compared to the laboratory control results. Survival less than 80 percent of the control value and t-test results between test samples and controls were used to determine impairment. Paleta Creek and Switzer Creek sample results were considered to be toxic (Tables F-2 and F-6).

Benthic community conditions were analyzed using diversity indices, a benthic index, and multivariate analyses. Benthic community results for the Paleta site stations were determined to be degraded. Analysis of benthic community conditions and sediment chemistry for San Diego Bay stations at the mouth of Paleta Creek displayed a definite relationship. Benthic communities were always found to be degraded when chemical levels exceeded the ERMQ.

Analysis of benthic community conditions and sediment chemistry for San Diego Bay stations at the mouth of Chollas Creek displayed a possible relationship; however, all three lines of evidence collected were not in complete agreement indicating other factors may have influenced the test results. Due to the size of the BPTCP program, sediment chemistry, toxicity tests, and benthic community assessment were not done on all samples.

Table F-1. BPTCP sediment chemistry data for Paleta Creek Channel

BPTCP Station	Total PAHs μg/kg	Total PCBs μg/kg	Chlordane μg/kg	ERMQ[a]
90009[b]	7,320	143.6	28.9	0.73
93227[b]	18,937	189.2	29.1	0.84
93228[b]	14,226	433.2	134.2	2.37
ERM	44,792	180	6	--
ERL	4,022	22.7	0.5	--

[a] ERMQ > 0.85 used as a screening value for elevated sediment chemistry
[b] Samples collected August 17, 1993
Source: Fairey et al. (1996)

Table F-2. BPTCP sediment toxicity and benthic community status for Paleta Creek Channel

Station	Amphipod 10-Day Survival Test[a]	Benthic Community Status
90009[b]	5%	DEGRADED
93227[b]	79%	DEGRADED
93228[b]	2%	DEGRADED

[a] Mean percent survival
[b] Samples collected August 17, 1993
Source: Fairey et al. (1996)

Table F-3. BPTCP sediment chemistry data for Chollas Creek Channel

BPTCP Station	Total PAHs µg/kg	Total PCBs µg/kg	Chlordane µg/kg	ERMQ[a]
90006[b]	11,188	79.7	67.6	1.06
93212[b]	6,270	39.6	36	0.59
93213[b]	11,074	86.4	83.8	1.23
ERM	44,792	180	6	--
ERL	4,022	22.7	0.5	--

Note: There was no sediment chemistry analysis for Stations 93170, 93182, and 93183
[a] ERMQ > 0.85 used as a screening value for elevated sediment chemistry
[b] Samples collected on August 4, 1993
Source: Fairey et al. (1996)

Table F-4. BPTCP sediment toxicity and benthic community status for Chollas Creek Channel

Station	Amphipod 10-Day Survival Test [a]	Sea Urchin Fertilization Test – 100% Porewater [b]	Sea Urchin Development Test – 100% Porewater [c]	Benthic Community Status
90006[d]	92%	17.1%	0%	Degraded
93212[d]	91%	0%	0%	Degraded
93213[d]	94%	93.4%	2.8%	Degraded
93170[e]	82%	66.1%	96.4%	NA
93182[f]	67%	0%	0%	NA
93183[f]	57%	82.7%	90.3%	NA

[a] Mean percent survival
[b] Mean percent successful fertilization
[c] Mean percent normal larval development
[d] Samples collected August 4, 1993
[e] Sample collected May 5, 1993
[f] Samples collected May 26, 1993
NA – not analyzed
Source: Fairey et al. (1996)

Table F-5. BPTCP sediment chemistry data for Switzer Creek Channel

BPTCP Station	Total PAHs µg/kg	Total PCBs µg/kg	Chlordane µg/kg	Lindane µg/kg	ERMQ[a]
90017[b]	60,882	162.5	16.3	< 0.2	1.18
90039[c]	11,933	27.9	32.8	< 0.2	0.84
90039[d]	24,375	229.2	40.4	8.24	2.14
ERM	44,792	180	6	--	--
ERL	4,022	22.7	2	--	--
TEL[e]	--	--	--	0.32	--

[a] ERMQ > 0.85 used as a screening value for elevated sediment chemistry
[b] Sample collected October 28, 1992
[c] Sample collected January 26, 1993
[d] Sample collected December 3, 1996
[e] Threshold Effects Level (MacDonald 1994)
Source: Fairey et al. (1996); Fairey et al. (1998)

Table F-6. BPTCP sediment toxicity for Switzer Creek Channel

Sample Station	Amphipod 10-Day Survival Testa	Sea Urchin Fertilization Test – 100% Porewaterb	Benthic Community Status
90017[c]	64%	1.3%	NA
90039[d]	38%	0.6%	NA
90039[e]	22%	38%	Degraded

[a] Mean percent survival
[b] Mean percent successful fertilization
[c] Sample collected October 28, 1992
[d] Sample collected January 26, 1993
[e] Sample collected December 3, 1996
NA – not analyzed
Source: Fairey et al. (1996); Fairey et al. (1998)

F1.2 NASSCO NPDES Marine Sediment Monitoring Data

From December 1992 through December 1997 and then in August 1999, NASSCO collected semi-annual sediment samples as part of a sediment monitoring program for WDR Order Nos. 85-05 (NPDES No. CA0107697) and 97-36 (NPDES No. CAG039001). Sediment from station NSS-STD-01, located at the outer channel of the Mouth of Chollas Creek, was analyzed for PAHs and PCBs. The sediment samples were collected from the upper 7 cm of sediment. A map showing the sample station location can be found in Figure F-1 and the sediment data are presented in Table F-7, below.

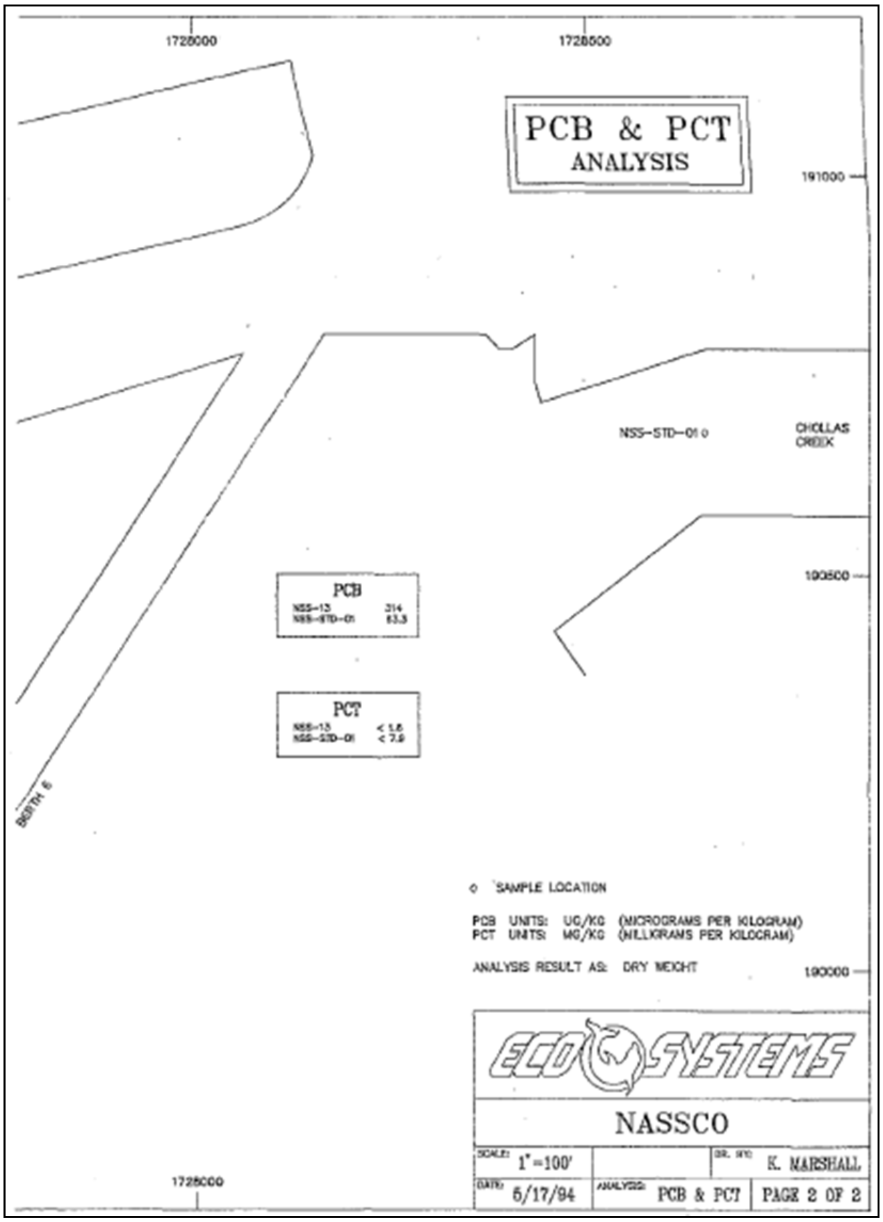

Figure F-1. Location of sample station NSS-STD-01
Source: Eco-Systems Mgmt, Inc. (1994)

Table F-7. NASSCO NPDES marine sediment monitoring in the mouth of Chollas Creek

Date	Total PAHs[1] µg/kg	Total PCBs µg/kg
December 30, 1992	4,644	ND
June 30, 1993	356	ND
December 30, 1993	4,189	ND
June 30, 1994	3,326	63.3
December 30, 1994	1,621	31.3
June 30, 1995	3,050	ND
December 30, 1995	ND	ND
June 30, 1996	ND	ND
December 30, 1996	2,557	ND
June 30, 1997	253	ND
December 30, 1997	4,236	ND
August 30, 1999	2,997	163
ERM	44,792	180
ERL	4,022	22.7

[1] Total PAHs is the sum of the following: Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, and Pyrene.
ND – not detected.
Source: Eco-Systems Mgmt, Inc. (1999)

F1.3 Detailed Sediment Investigation Data for NASSCO Station NA22

In 2001 and 2002, NASSCO and Southwest Marine Inc. (now BAE Systems) conducted a detailed sediment investigation to determine the existence and extent of potential beneficial use impairment in San Diego Bay attributable to chemicals associated with historical operations at the shipyards (Exponent 2003). Station NA22 is located in the Chollas Creek Mouth study area, illustrated in Figure F-2. The area represented by Station NA22 and located in the Chollas Creek Mouth study area has been excluded from Cleanup and Abatement Order No. R9-2012-0024 and is included in this TMDL project. The surface sediment chemistry, toxicity and benthic communities data from the Shipyard Sediment Site Study for this station is presented in the Tables F-8 through F-10.

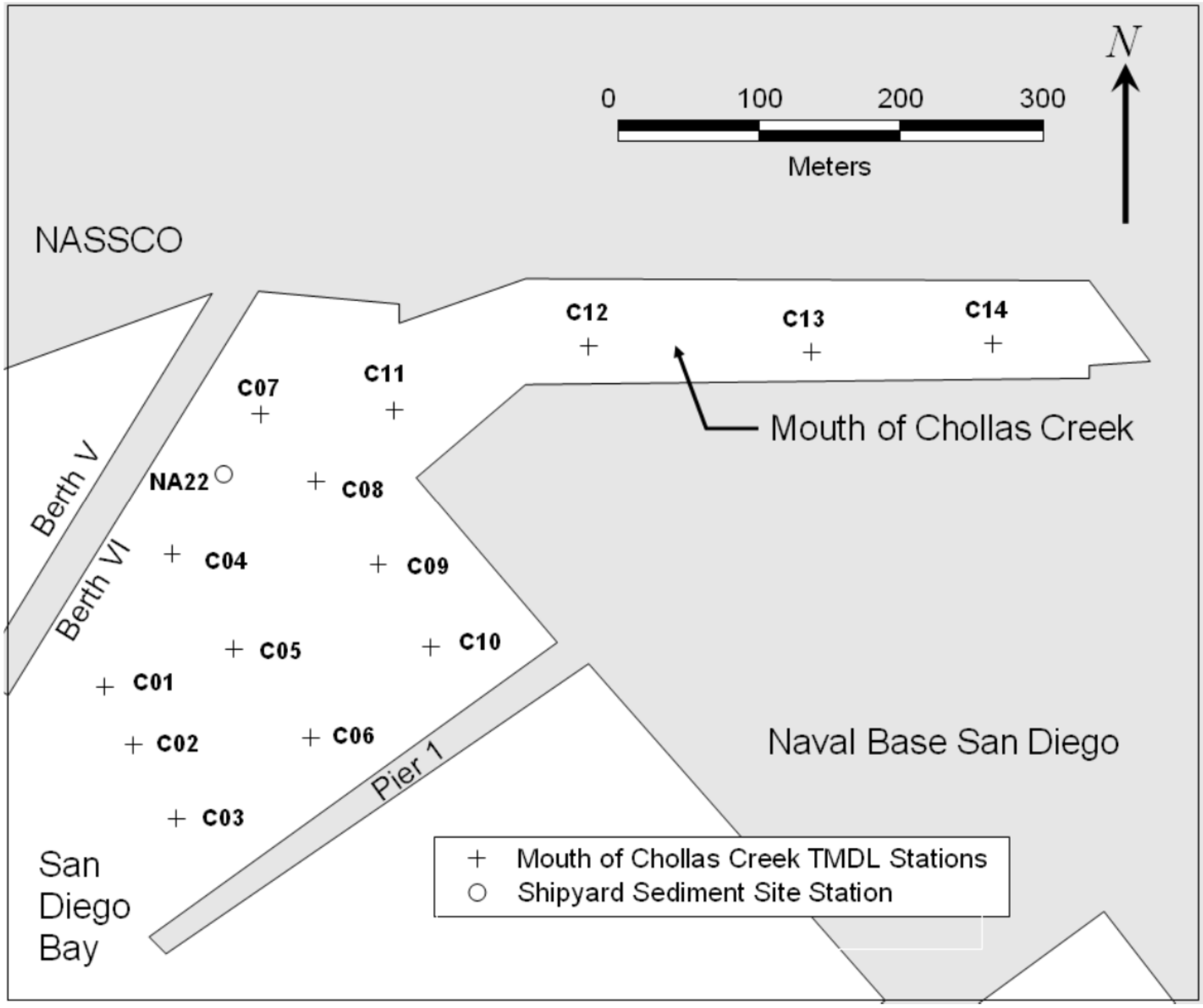

Figure F-2. Chollas Creek Mouth Study Area and Shipyard Sediment Site Study Area Sample Location NA22
Source: RWQCB (2010)

Table F-8. Sediment chemistry data for Shipyard Sediment Site Study Area Sample Location NA22

Date	LMWPAH[1] µg/kg	HMWPAH[2] µg/kg	Total PAHs[3] µg/kg	Total PCBs[4] µg/kg	Total Chlordane[5] µg/kg
8/14/2001	380	3,600	4,000	180	--
9/12/2002	--	--	--	--	21.1
ERM	3,160	9,600	44,792	180	6
ERL	552	1,700	4,022	22.7	0.5

[1] Total LMWPAH is computed as the sum of the concentrations of naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. Sums were calculated using one-half the quantitation limit for those compounds that were not detected.
[2] Total HMWPAH is computed as the sum of the concentrations of fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenz[a,h]antracene, and benzo[ghi]perylene. Sums were calculated using one-half the quantitation limit for those compounds that were not detected.
[3] Total PHA is computed as the sum of the concentrations of the compounds listed in table endnotes 1 and 2. Sums were calculated using one-half the quantitation limit for those compounds that were not detected.
[4] Total PCBs is computed as the sum of 41 PCB congeners. Sums were calculated using one-half the quantitation limit for those compounds that were not detected.
[5] Total chlordane is computed as the sum of α-chlordane and γ-chlordane.
Source: Exponent (2003)

Table F-9. Sediment toxicity tests results for Shipyard Sediment Site Study Area Sample Location NA22 and reference stations

Station	Amphipod 10-day Survival Test – Whole Sediment Mean (percent survival)	Mussel Larval Development Test – Sediment-Water Interface Mean (percent live normally developed larvae)	Sea Urchin Fertilization Test – 100% Porewater Mean (percent eggs fertilized)
Control			
Batch 1	99	81	94
Batch 2	100	71	92
Batch 3	97	--	75
Reference			
2441	95	66	83
2433	93	47	73
2440	97	70	81
2231	84	82	93
2243	89	50	69
NASSCO Station			
NA22	92	1.8[a]	83

[a] Statistically different from reference pool.
Source: Exponent (2003)

Table F-10. Benthic community measures for Shipyard Sediment Site Study Area Sample Location NA22 and reference stations

Station	Abundance	Number of Taxa	Shannon-Wiener Diversity	Benthic Response Index Level
Reference Stations				
2441	505	47.8	2.8	Reference
2433	440	34.8	2.57	Reference
2440	639	39	2.72	I
2231	6,232	64	0.79	Reference
2243	987	39	2.49	II
Mean Value[a]	643	40.2	2.65	--
NASSCO Station				
NA22	107[b]	15[b]	2.18[b]	II

[a] Excludes data for Station 2231.
[b] Value is significantly less ($p \leq 0.05$) than mean reference value.
Source: Exponent (2003)

F1.4 Navy Maintenance Dredging Sediment Data

In August 1997, the U.S. Navy dredged approximately 75,700 cubic meters of bay sediment from the Chollas Creek Channel adjacent to Naval Station San Diego. In preparation for the dredging, the Navy conducted site characterization studies of the Chollas Creek Channel sediment in 1992 and 1995. The assessments included physical, biological, and chemical analyses of the sediment that was removed.

In January 1995, the U.S. Navy conducted a sediment characterization study to obtain permits necessary for dredging and disposal of bay material. The study involved collection of cores from eighteen locations throughout the proposed dredge footprint (Figure F-3). In the outer mouth area near the opening of the channel to the bay, cores 1 through 6 and core 8 were analyzed as one section. In the inner creek mouth area near the headwall, cores 9, 11, and 13 through 18 were split into subsections (representing surface, middle, and bottom sediment layers). The three sediment layers represented the area of the sediment column that ranged from 0 to -7 feet (0 to -2.1 meters), -7 to -14 feet (-2.1 to -4.3 meters), and -14 to -22 feet (-4.3 to -6.7 meters) below the sediment surface (Ogden 1995).

The core locations are shown in Figure F-3 and a graphic representation of the sediment layers profile and the mean depth of the creek bed is shown in Figure F-4.

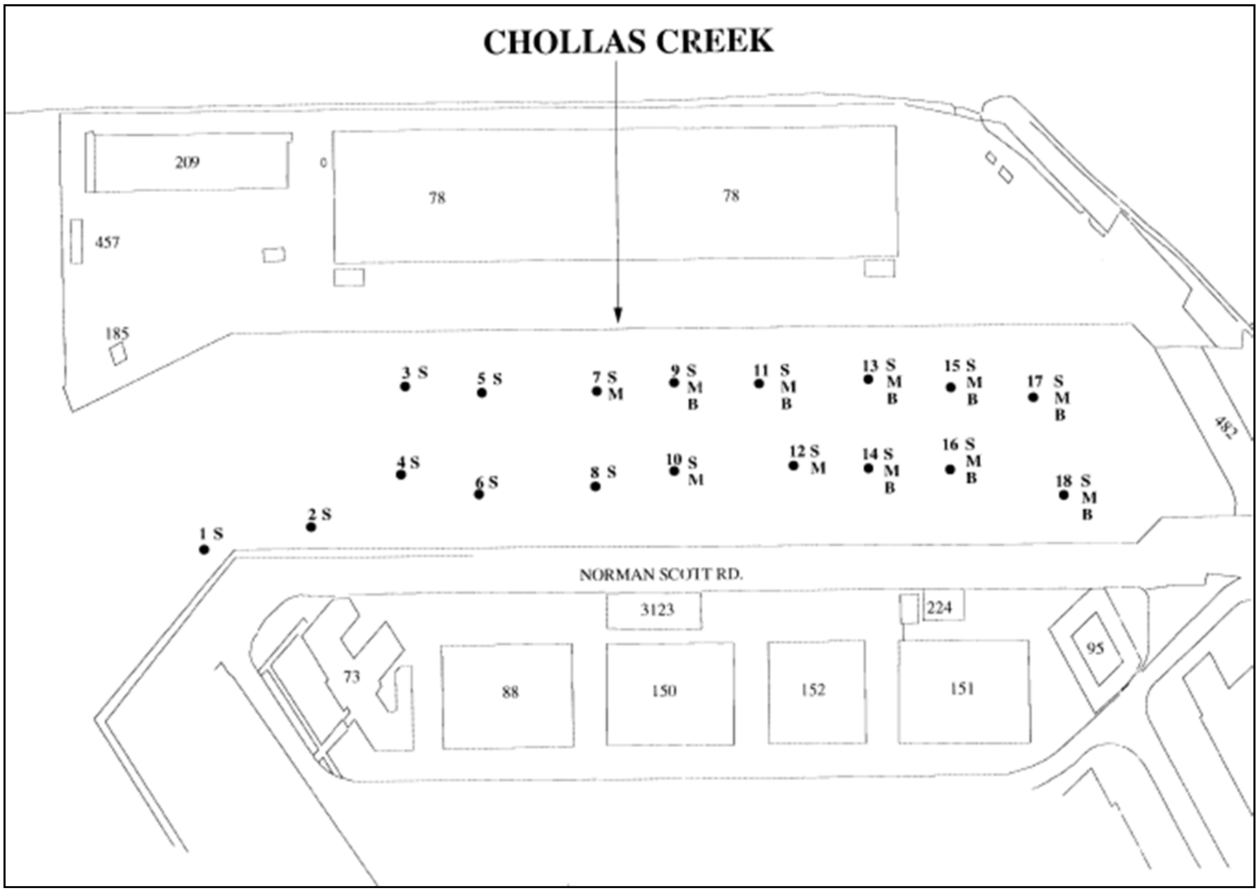

Figure F-3. Core locations for January 1995 Sediment Characterization Study
Source: U.S. Navy (1996)

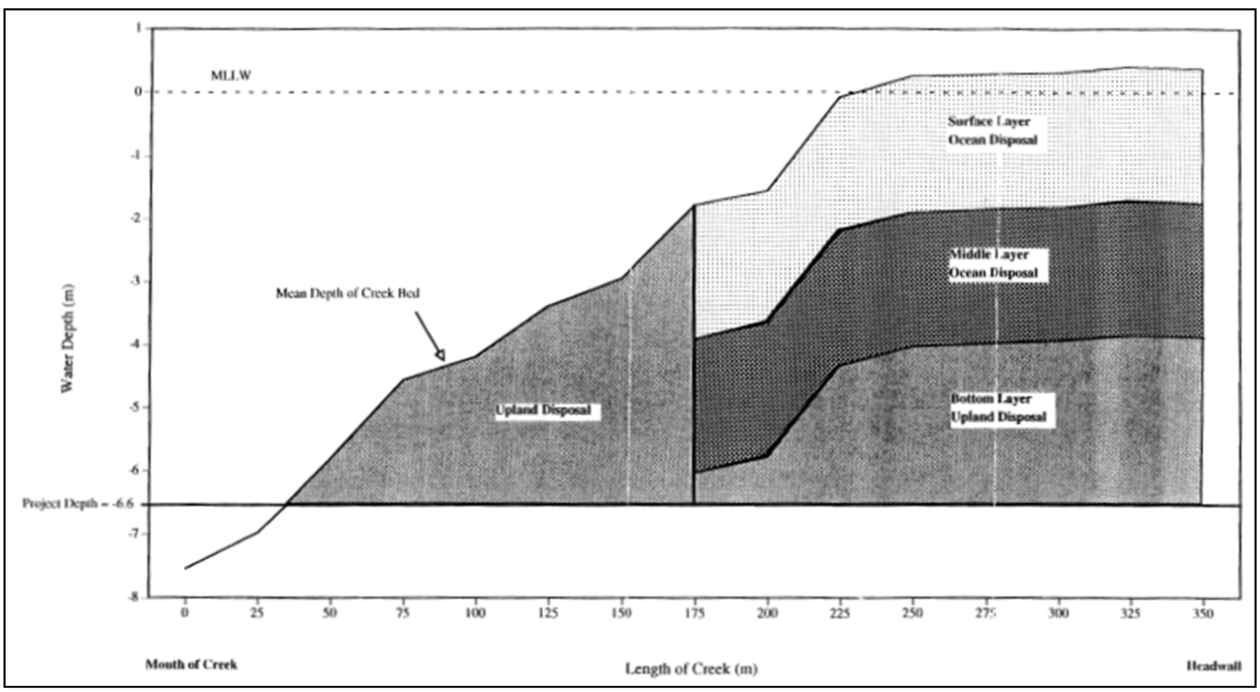

Figure F-4. Cross-section of Chollas Creek from mouth to headwall

Source: U.S. Navy (1996)

In general, results indicated that the highest chemical concentrations were found in discrete layers of the sediment column and within discrete locations in the study area. Chemical concentrations were highest in the surficial sediments near the outer mouth area, and in the bottom layer towards the head of the creek below a depth of 14 feet (4.3 meters) into the sediment column. Chemical levels decreased significantly in the middle and surface layers in the area near the head of the creek mouth (U.S. Navy 1997).

A summary of chemical data from core samples in the inner and outer creek mouth areas is presented in Table F-11.

Table F-11. Dredging project for Chollas Creek Channel – bulk sediment chemistry (January 1995)

Sample Number	Layer m	Total PAHs µg/kg	Total PCBs[1] µg/kg	Chlordane µg/kg
Core 1	surface – -2.1	9,510	284	260
Core 2	surface – -2.1	4,630	256	240
Core 3	surface – -2.1	14,760	256	150
Core 13	surface – -2.1	1,620	221	< 63
	-2.1 – -4.3	2,150	252	130
	4.3 – 6.7	3,150	245	180
Core 14	surface – -2.1	1,470	245	82
	-2.1 – -4.3	490	221	90
	-4.3 – -6.7	4,410	235	170
Core 15	surface – -2.1	490	210	< 63
	-2.1 – -4.3	180	210	86
	-4.3 – -6.7	2,510	273	1,110
Core 16	surface – -2.1	260	221	< 60
	-2.1 – -4.3	1,760	228	150
	-4.3 – -6.7	4,170	308	160
Core 17	surface – -2.1	180	207	< 59
	-2.1 – -4.3	510	224	100
	-4.3 – -6.7	1,750	235	140
Core 18	surface – -2.1	15,780	207	64
	-2.1 – -4.3	1,310	203	140
	-4.3 – -6.7	660	221	100
ERM		44,792	180	6
ERL		4,022	22.7	0.5

[1] PCB reported as non detect for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Total PCB values were calculated by summation of one-half the detection limit of each non detected Aroclor.

Source: Ogden (1995)

Additional data was collected in November 1995 to assess the potential for ocean disposal of previously untested sediment that had deposited after the initial study was conducted in 1992. This “new” sediment had been deposited after several major rainfall events in 1993 and 1994 at the Mouth of Chollas Creek (U.S. Navy 1996). The study consisted of 16 cores (Figure F-5), split into 2 sediment layers that ranged from 0 to -7 feet (0 to 2.1 meters) and -7 to -14 feet (2.1 to 4.3 meters) below the sediment surface. Each sediment layer from the 16 cores was composited into 1 sample for analysis. The results of the study indicated that the recently deposited sediment met disposal criteria for placement at the ocean disposal site.

A summary of the chemical and biological data is presented in Tables F-12 and F-13.

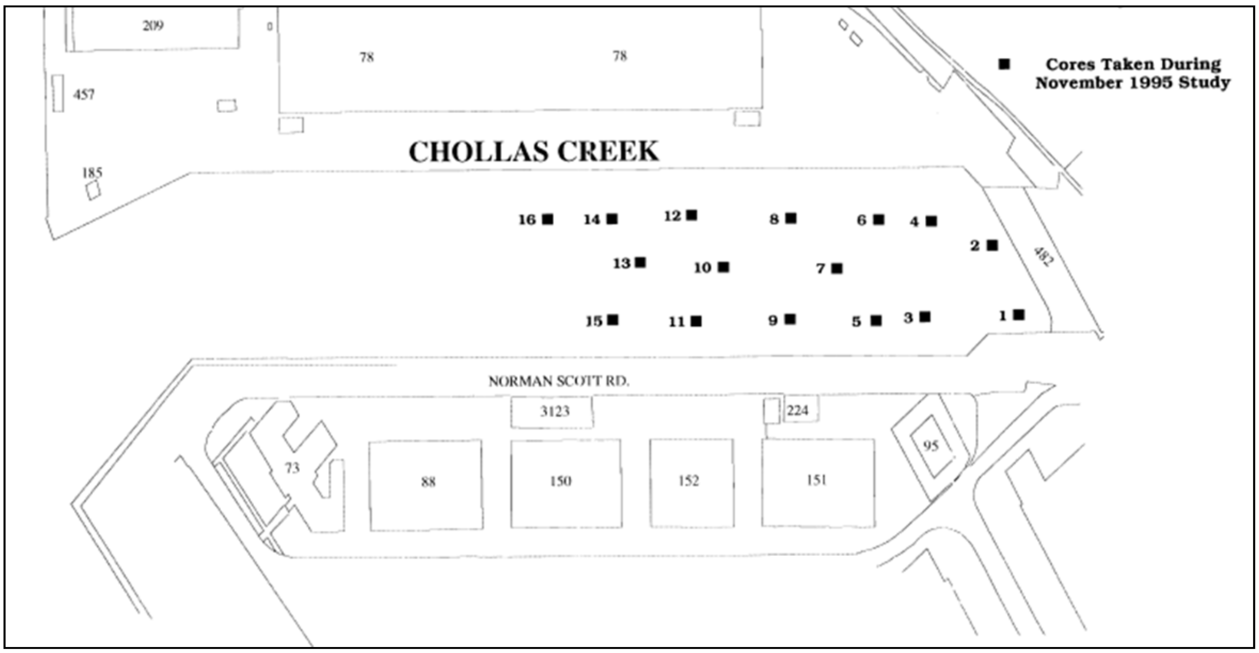

Figure F-5. Core locations for November 1995 Sediment Characterization Study
Source: U.S. Navy (1996)

Table F-12. Dredging project for Chollas Creek Channel – bulk sediment chemistry (November 1995)

Station	Total PAHs µg/kg	Total PCBs[1] µg/kg	Chlordane µg/kg
Top Composite[2]	861	74	57
Bottom Composite[3]	2,581	81	76
ERM	44,792	180	6
ERL	4,022	22.7	0.5

[1] PCB reported as non detect for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Total PCB values were calculated by summation of one-half the detection limit of each non detected Aroclor.
[2] Composite of top sediment layer (surface to -2.1 meters) of 16 core samples
[2] Composite of bottom sediment layer (-2.1 to -4.3 meters) of 16 core samples
Source: U.S. Navy (1996)

Table F-13. Dredging project for Chollas Creek channel – toxicity

Station	Suspended Particulate Phase			Solid Phase
	Sanddab Survival Test – 100% Elutriate[1]	Mysid Shrimp Survival Test – 100% Elutriate[1]	Sea Urchin Development Test – 100% Elutriate[2]	Amphipod – % Survival[3]
Top Composite[4]	100%	98%	1%	82%
Bottom Composite[5]	2%*	84%	0%	88%

[1] Mean percent survival
[2] Mean percent normal larval development
[3] Percent survival
[4] Composite of top sediment layer (surface to -2.1 meters) from 16 core samples
[5] Composite of bottom sediment layer (-2.1 to -4.3 meters) from 16 core samples
* Indicates value significantly less than control ($p \leq 0.05$)
Source: U.S. Navy (1996)

F1.5 Naval Base San Diego Sediment Quality Characterization Data

The U.S. Navy conducted the Sediment Quality Characterization Study to assess the status of sediment quality in the vicinity of Naval Station San Diego (now called Naval Base San Diego) in San Diego Bay. The study's focus was to characterize sediment concentrations, related biological measurements, and the extent of contamination. The study also evaluated chemical sources, sediment transport, sediment-water exchange, and degradation (Chadwick et al. 1999).

Data were collected at stations NSB-5 (mouth of Paleta Creek) and NSB-6 (reference station) in 1995 and 1997. NSB-5 is located in the mouth of Paleta Creek and NSB-6 is located in the open water of San Diego Bay near Silver Strand across from Piers 1 and 2. All of the data provided in this section has been summarized from Chadwick et al. (1999).

Organics (PAHs and PCBs) data were measured in sediments at station NSB-5 and NSB-6 (Table F-14). PAH concentrations at NSB-5 were higher than the reference station (NSB-6) in 1995 and 1997. The Paleta Creek station (NSB-5) had PAH and PCB values above the ERL, but below the ERM in 1995; however, total PAHs were above the ERM in 1997. These two stations and others were analyzed for PCBs and pesticides in 1997 and levels of these chemicals were elevated at all stations, indicating a gradient with concentrations decreasing with distance away from Naval Base San Diego (Chadwick et al. 1999). The 1997 PCB data was not presented in the referenced report.

Table F-14. PAHs and PCBs in bulk sediments

Year Sampled	Pollutant	Units[1]	NSB- 5	NSB- 6	NSB- 6 (rep)	ERL	ERM
1995	Total PAHs	µg/kg	16,900	548	508	4,022	44,792
1997	Total PAHs	µg/kg	45,850	533	--		
1995	Total PCBs	µg/kg	22	43	--	22.7	180

[1] Dry weight
Source: Chadwick et al. (1999)

PAHs and PCBs were also measured in pore waters at stations NSB-5 and NSB-6 (Table F-15). Total PAH and total PCBs fell below U.S. EPA's acute saltwater water quality criteria (WQC); however, total PCBs were in the range of U.S. EPA's chronic water quality criteria.

Table F-15. PAHs and PCBs in porewater samples

Pollutant	Units	NSB-5	NSB-6	WQC Saltwater Criteria[1]	
				Acute	Chronic
Total PAHs	ng/L	3.74	1.12	300	--
Total PCBs	ng/L	32.21	29.97	10,000	30

[1] Proposed Water Quality Criteria (U.S. EPA 1997)

Source: Chadwick et al. (1999)

A series of bioassay tests were conducted to estimate the potential effects of marine sediments on various test organisms (Table F-16). The endpoints measured were the concentration at which 50 percent of test organisms were affected (LC_{50} or IC_{50}) and the concentration at which no observable effect occurred (the No Observable Effect Concentration or NOEC). LC_{50} is the lethal concentration at which 50 percent of the organisms do not survive and IC_{50} is the inhibition concentration at which 50 percent of the organisms are inhibited (e.g., reduction in light emitted or loss of mobility). Both sediment leachates and pore waters were tested. The endpoints were survival in the shrimp and minnow (LC_{50}), inhibition of bioluminescence of the dinoflagellate and bacterium (IC_{50}), and biomass or chlorophyll florescence in the diatom tests (IC_{50}).

Sediment elutriate test results showed that sediments at station NSB-5 can produce effects due to leaching of contaminants. PAHs were considered to be a possible agent for the effects measured at station NSB-5 because higher levels of PAHs were observed in pore waters at this station.

Table F-16. Summary of bioassay results from sediment elutriate studies (reported as percent elutriate, causing an LC50 or IC50 for various test organisms)

Station	Shrimp (*Mysidopsis*) elutriate	Minnow (*Menidia*) elutriate	Diatom (*Skeletonema*) elutriate	Microtox (bacterium) elutriate	QwikLite (dinoflagellate) elutriate	QwikSed (dinoflagellate) pore water
NSB-5	61.5%	*	43.4%	*	6.4%	**
NSB-6	*	*	*	*	31.0%	*

*Indicates that the LC50 or the IC50 was greater than the 100 percent elutriate and effects were not observed.
**Indicates that some effects were observed at 50 percent concentration and no IC50 was generated.
Source: Chadwick et al. (1999)

The bioaccumulation of sediment and water-associated chemicals, and biological responses to chemicals were examined at the Naval Base San Diego and reference stations. Mussels (*Mytilus edulis* and *Musculista senhousia*) collected at the reference stations were transplanted in and around Naval Base San Diego for a study period of 30 days. Tissue and sediment chemical concentrations were statistically compared to the reference station (NSB-6). The tissue and sediment samples were consistently higher at station NSB-5 than the reference station (Table F-17).

Table F-17. Tissue and sediment chemical concentrations compared to the reference station

Station	Chemical	Sample tissue (M. edulis)	1997 Sediment	Sample tissue (M. senhousia)	1995 Sediment
NSB-5	PCBs				x
NSB-5	Pesticides	x		x	x
NSB-5	Total PAHs	x	x	x	x

X indicates that chemicals are at statistically higher levels than the reference station
Source: Chadwick et al. (1999)

In conjunction with the bioaccumulation measurements, the growth of the transplanted mussels was measured as well as a biomarker (stress sensitive biochemical indicator). DNA damage was the biomarker used in this study.

Bioaccumulation, growth, and DNA damage experiments were conducted in 1995 (*Mytilus edulis*) and 1997 (*Musculista senhousia*). In the 1995 study, station NSB-5 had lower growth than the reference station (NSB-6) (Table F-18). The 1997 *Musculista senhousia* results were consistent with the 1995 *Mytilus edulis* results. Survival and growth were higher at the reference station (NSB-6) (Table F-19). PAHs and pesticides were higher in mussel tissues at station NSB-5 than NSB-6 (Table F-20; pesticide data not shown).

Table F-18. Mytilus edulis growth (1995)

Station	Days of growth	Weight		Length	
		% Difference	% Difference/day	% Difference	% Difference/day
NSB-5	33	18.3 ± 6.7	0.55	7.0 ± 4.8	0.21
NSB-6	32	32.0 ± 12.8	1.00	11.1 ± 5.0	0.35

Source: Chadwick et al. (1999)

Table F-19. Musculista senhousia growth (1997)

Station	Mean % Survival	Growth	
		Mean % weight gain	Mean % length gain
NSB-5	70%	30%	6.1%
NSB-6	84%	42.6%	12%

Source: Chadwick et al. (1999)

Table F-20. Chemical bioaccumulation in Mytilus edulis tissues (1995) and Musculista senhousia tissues (1997)

Station	Total PAHs (1995) (μg/kg wet weight)	Total PAHs (1997) (μg/kg wet weight)
NSB-5	1,620	3,246
NSB-6	403	904

Source: Chadwick et al. (1999)

The mussels at station NSB-5 (Paleta Creek) showed significant DNA damage and growth effects compared to the reference station (Table F-21). PCBs were not bioaccumulated at levels greater than the reference station, and pesticides were available and elevated in the tissue of both mussel species at station NSB-5. The water column filter feeders (*M. edulis*) seemed sensitive to contaminants in the water column indicating bioavailability through sediment resuspension. The sediment-dwelling *M. senhousia* were more sensitive to PAHs and responded significantly at the stations where high concentrations of PAHs were in the sediments and bioavailable (i.e., inside Paleta Creek).

Table F-21. Musculista senhousia growth and DNA damage (1997)

Station	Mussel Count	Survival	Growth		DNA Damage (Tail moment)		
			% weight gain	% length gain	Germ[a]	G1[b]	G2[b]
NSB-5	50	65%	12.1	3.0	9.1 ± 1.1 (52)[cd]	2.6 ± 0.3 (187)	3.8 ± 1.3 (11)
NSB-6	50	87%	63	12.8	4.0 ± 0.7 (74)	2.9 ± 0.4 (155)	3.1 ± 1.1 (21)

Tail moment figures are presented as the mean plus or minus the standard deviation with number of cells in parentheses. Higher tail moment values indicate greater damage.

[a] Germ cells are sperm cells, which do not have repair capabilities

[b] G1 or G2 cells are normal tissue (somatic) cells. Designation at G1 or G2 depends on the amount of DNA within the cell.

[c] $p<0.001$, indicating that there is a 0.1 percent chance that a random sample would result in a difference large enough to be considered significant.

[d] The number in parentheses equals the number of cells

Source: Chadwick et al. (1999)

F1.6 Tenth Avenue Marine Terminal Maintenance Dredging

The Port of San Diego funded a dredging project that was performed at the Tenth Avenue Marine Terminal (TAMT) in November-December 1993 (MEC Analytical Systems, Inc. 1991). The dredging was required to maintain adequate depths (-9.1 meters) for berthing and maneuvering for ships that use the berths at the terminal. Chemical testing of the sediment was required to determine suitability of the sediment for ocean disposal. Sediments were collected previous to the dredging operation in October 1991. Table F-22 presents the sediment results for the contaminants of concern.

Table F-22. Contaminants of concern in sediments at Berths 10-1 and 10-2 at Switzer Creek Mouth in 1991

Analyte	Detection Limit	Site 1 μg/kg dry	Site 2 μg/kg dry	Site 3 μg/kg dry	Site 4 μg/kg dry	Site 5 μg/kg dry
Total PAHs	*	3,614	3,316	3,259	3,690	3,096
PCB 1254	20	360	481	434	394	178
Chlordane	25	ND	ND	ND	ND	ND

* Total PAH is a combination of several PAHs with several different detection limits.
Source: MEC Analytical Systems Inc. (1991)

No pesticides or PCBs were detected above the detection limits of the analysis except for PCB (Aroclor) 1254. PCB 1254 was found at high concentrations (178 – 481 μg/kg dry weight) at all five sites. Note that the detection limit for chlordane (25 μg/kg) is much higher than the threshold levels of concern (such as ERLs, which are 0.5 μg/kg).

In addition, PAHs concentrations (3,096 – 3,690 μg/kg dry weight) were elevated at all five sites. The following PAHs that produced readings above detection at four to five of the sites include: acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene.

The Port of San Diego funded another maintenance dredging project at the TAMT facility in September and October 2002 (AMEC Earth & Environmental, Inc. 2002). The project area at Berths 10-1 and 10-2 was dredged to -32 feet (-9.8 meters) MLLW with a 1 foot (.3 meter) over-dredge allowance. The total volume removed was 16,100 cubic yards of sediment. Figure F-6 shows the dredge footprint of the project.

Figure F-6. 2002 dredge area and sample locations at the Tenth Avenue Marine Terminal
Source: AMEC Earth & Environmental, Inc. (2002)

Sediment characterization, including sediment chemistry, toxicity testing, and bioaccumulation testing was conducted for determination of disposal options (AMEC Earth & Environmental, Inc. 2002). Five locations were sampled within each of the two sites at berths 10-1 and 10-2 for a total of ten sample locations. Samples consisted of core samples from each location that were composited and homogenized for testing. Field log noted that cores from 7 of the 10 sites contained black fine sand, black silt with fine sand, gray black silt, or black medium sand with petroleum odors or specks. Figure F-6 shows the locations of the ten sample sites. Table F-23 presents the sediment chemistry results.

Table F-23. Contaminants of concern in sediments at Berths 10-1 and 10-2 at Switzer Creek Mouth in 2002

Analyte	Site 1-1 µg/kg dry	Site 1-2 µg/kg dry	Site 1-3 µg/kg dry	Site 1-4 µg/kg dry	Site 1-5 µg/kg dry	Site 2 Composite µg/kg dry
Total PAHs	9,170	4,240	6,040	5,490	11,050	3,720
PCB 1254	89	110	200	170	170	230
Chlordane	65	85	120	120	140	130

* The reference site values were non-detect for each of the three analytes.
Source: AMEC Earth & Environmental, Inc. (2002)

The three groups of organics of concern were found at concentrations that exceeded guideline values. The ERL for Total PAHs of 4,022 µg/kg was exceeded at all five of the Berth 10-1 sites, but not the Berth 10-2 composite sample. The same individual PAHs (except for acenaphthylene) that exceeded the ERL guideline value in the 2002 sampling event also exceeded the guideline value in the1993 sampling event.

Of the pesticides analyzed, chlordane was the only pesticide observed. Chlordane results in all sediment samples exceeded the ERM value of 6 µg/kg.

PCBs (Arochlor 1254) exceeded the ERM value of 180 µg/kg in the Site 1-3 sample and the Site 2 composite sample. All samples exceeded the ERL of 22.7 µg/kg.

F1.7 Phase I Sediment Assessment Study for the Mouths of Paleta, Chollas, and Switzer Creeks

In 2001 and 2003, sediment assessment studies were conducted to help characterize the extent of contamination, toxicity, and benthic community impacts at the areas around the mouths of Paleta, Chollas, and Switzer creeks. In the case of Paleta and Chollas Creeks, bioaccumulation exposure experiments were conducted for the purpose of performing a screening level risk assessment for human health. The *Sediment Assessment Study of Chollas and Paleta Creek Mouths* (Phase I Study for the TMDL) (SCCWRP and SPAWAR 2005) and *Sediment Quality Assessment Study at the B Street/Broadway Piers, Downtown Anchorage, and Switzer Creek* (Phase I Study for the TMDL) (Anderson et al. 2004) followed the approach from two previous San Diego Bay sediment studies, the Bay Protection and Toxic Cleanup Plan and the Southern California Bight 1998 Regional Marine Monitoring Survey (Bight 1998). These previous approaches measured multiple indicators of sediment quality and used a multiple lines of evidence approach to identify areas of impaired sediment quality.

The Phase I sediment assessment studies included the collection of sediment data that were used to reconfirm that a problem exists and better identify the areas of greatest concern for further detailed investigations in the development of TMDLs. Surface sediment data were collected throughout the Paleta, Chollas, and Switzer creeks study areas (in and around the mouths of the creeks) and at designated bay reference stations. Three lines of evidence of sediment quality were used to assess aquatic life impairment including sediment chemistry, sediment toxicity, and benthic community composition. The locations of the reference stations for Paleta and Chollas creeks and Switzer Creek are shown in Figures F-7 and F-8, respectively. The locations of the sampling stations at the mouths of Paleta, Chollas, and Switzer creeks are presented in Figures F-9, F-10, and F-11, respectively.

Phase I results for Paleta, Chollas, and Switzer creeks are summarized in Tables F-24 through F-33.

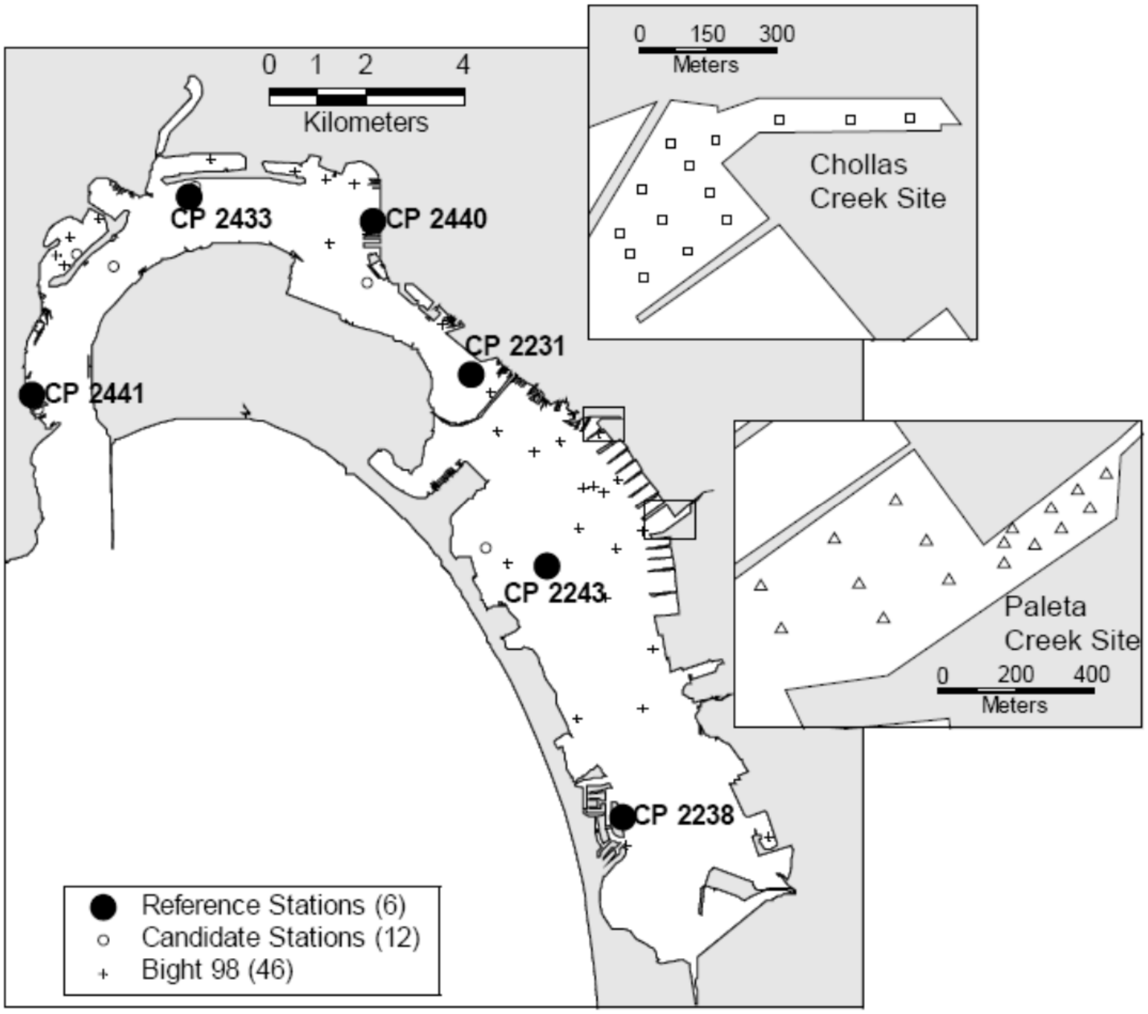

Figure F-7. San Diego Bay reference stations for Paleta and Chollas Creeks Phase I Sediment Assessment

Source: SCCWRP and SPAWAR (2005)

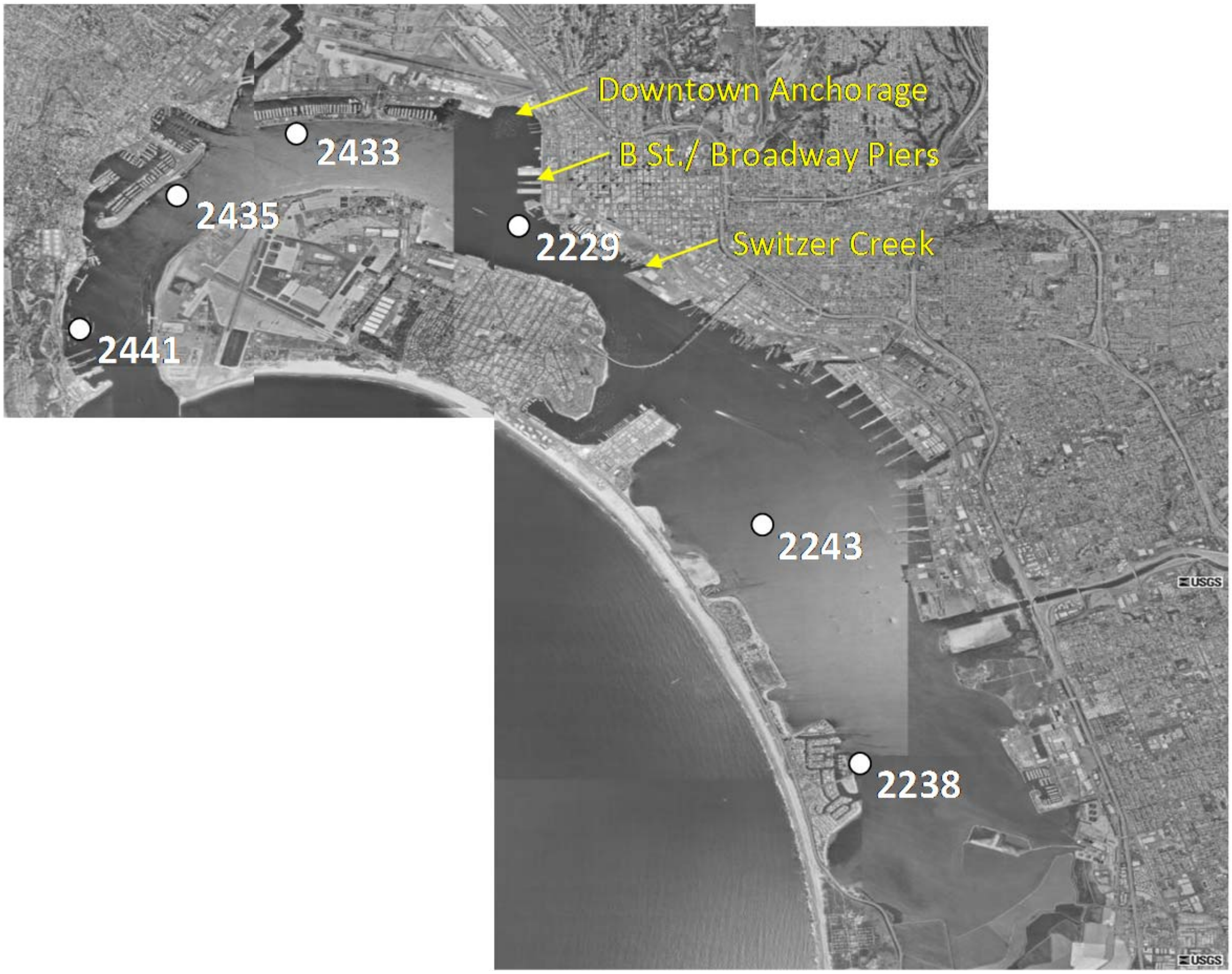

Figure F-8. San Diego Bay reference stations for Switzer Creek Phase I Sediment Assessment
Source: Anderson et al. (2004)

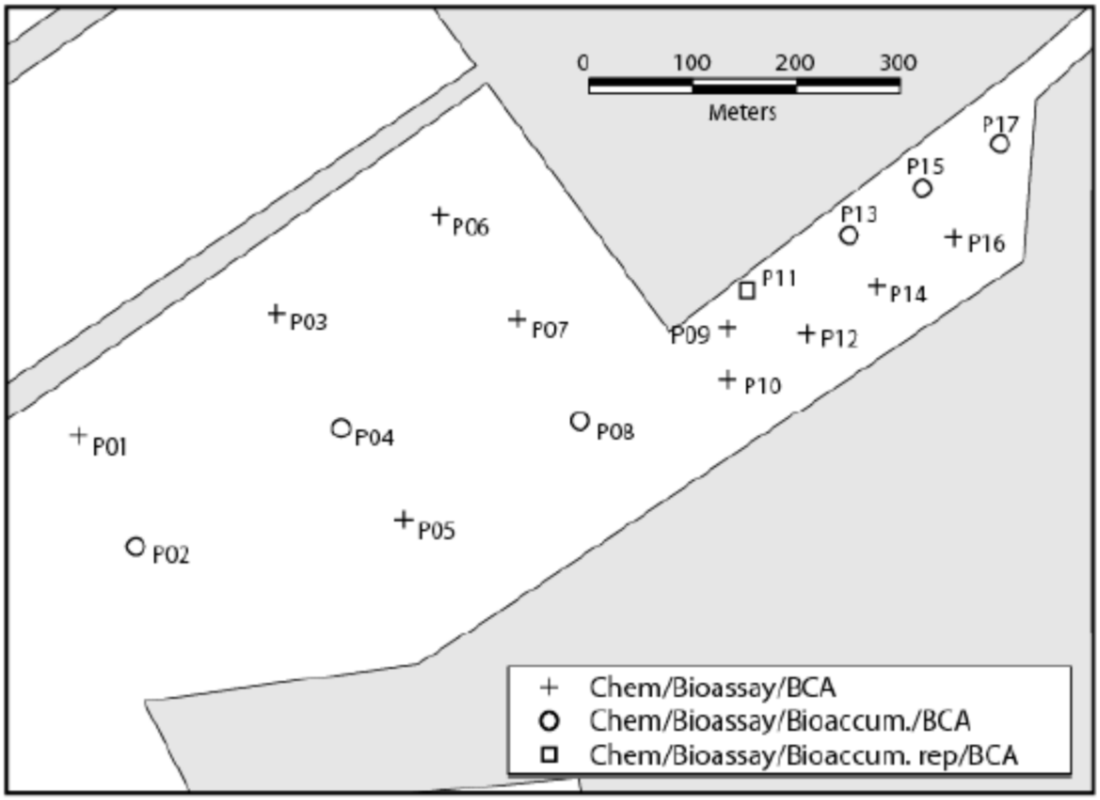

Figure F-9. Paleta Creek sampling stations for chemistry, bioassays, bioaccumulation, and benthic community assessment for the Phase I Sediment Assessment

Source: SCCWRP and SPAWAR (2005)

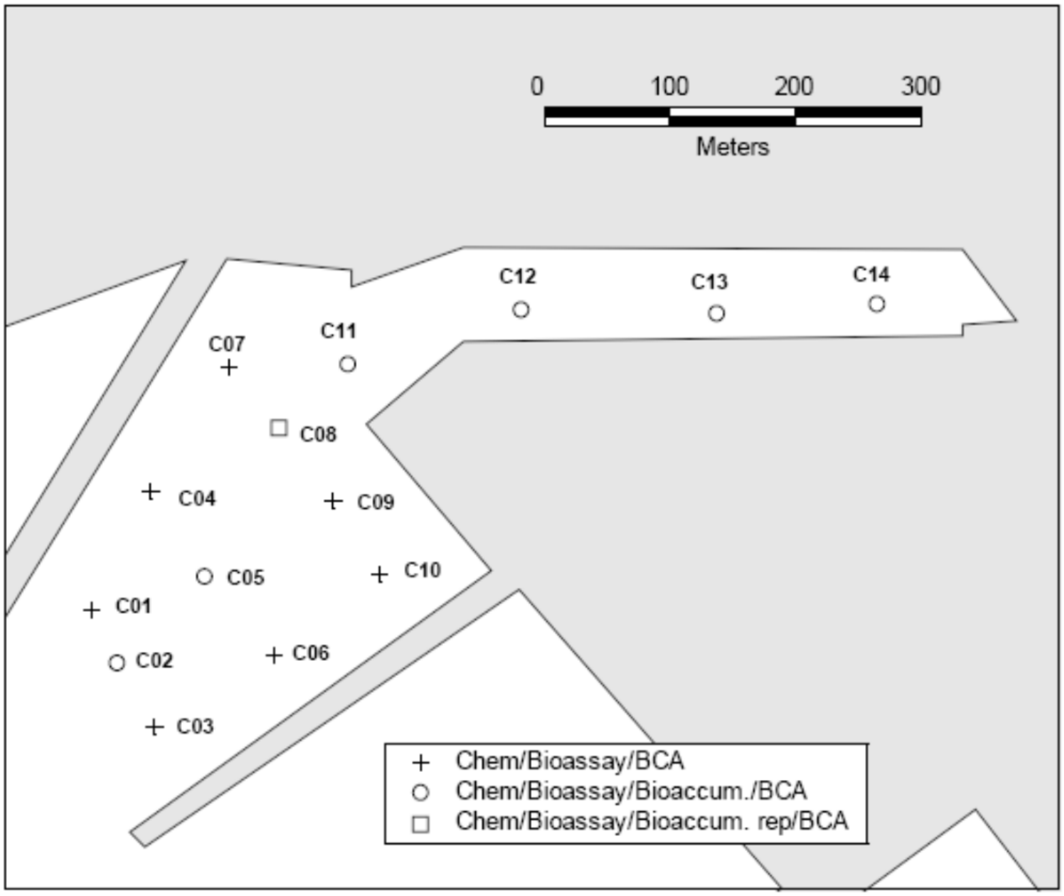

Figure F-10. Chollas Creek sampling stations for chemistry, bioassays, bioaccumulation, and benthic community assessment for the Phase I Sediment Assessment
Source: SCCWRP and SPAWAR (2005)

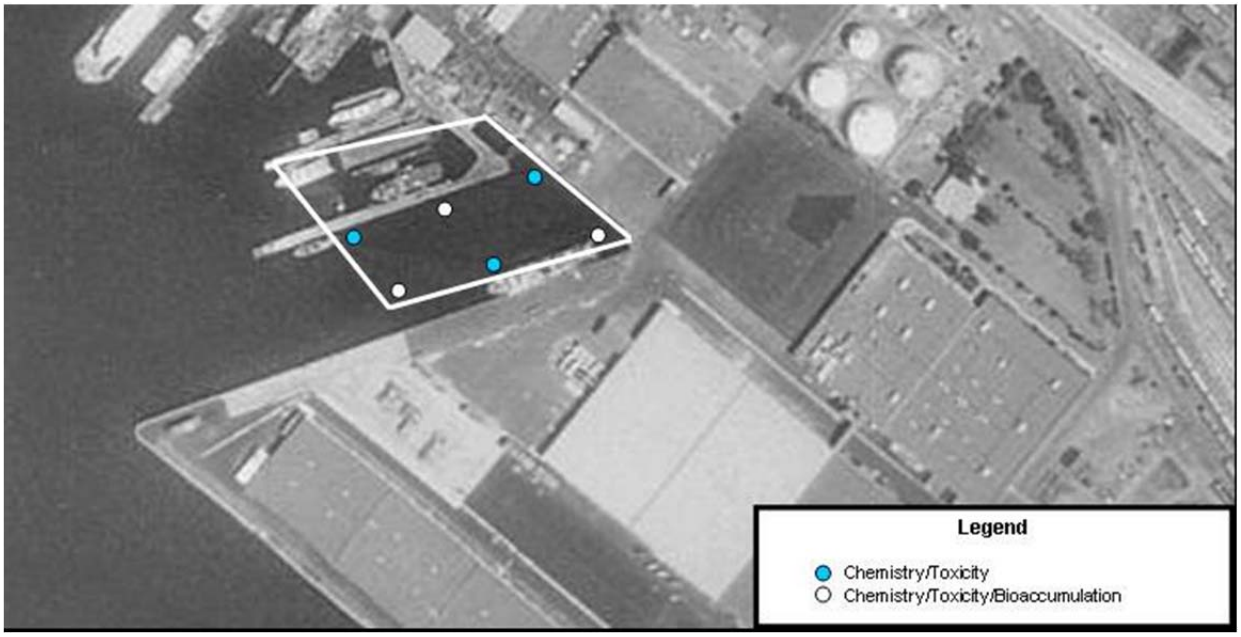

Figure F-11. Switzer Creek sampling stations for chemistry, bioassays, bioaccumulation, and benthic community assessment for the Phase I Sediment Assessment
Source: Anderson et al. (2004)

F1.7.1 Sediment Chemistry

Paleta Creek

The total PAH mean sediment concentration at the Paleta Creek mouth site exceeded the reference station mean by a factor of 3. The highest concentrations were located in the inner channel. While none of the Paleta stations exceeded the ERM for total PAHs, all but five stations exceeded the ERL.

Total PCB concentrations in sediment at the Paleta Creek mouth site exceeded the reference station mean by a factor of 2.5. The highest concentration was found at station P05, near the mole pier. Six of the Paleta Creek stations' concentrations exceeded the ERM value for total PCBs and all of the stations exceeded the ERL.

Pesticide results for the Paleta Creek stations indicate that total chlordane exceeded the reference station mean concentrations by 2.75 times. The inner channel stations had the highest concentrations with six station concentrations exceeding the ERM value for total chlordane. Table F-24 presents the sediment chemistry for the mouth of Paleta Creek.

Table F-24. Sediment chemistry data for Paleta Creek site and reference stations

Area	Station	LMWPAH[1] µg/kg	HMWPAH[2] µg/kg	Total PAHs µg/kg	Total PCBs[3] µg/kg	Total Chlordane µg/kg
Reference	CP 2231	86	536	1,591	43	0.9
	CP 2238	17	103	288	12	0.2
	CP 2243	20	118	387	21	0.2
	CP 2433	56	415	1,166	27	0.6
	CP 2440	1,052	3,049	8,061	283	16.2
	CP 2441	236	1,210	3,208	34	0.8
	Mean	245	905	2,450	70	3.2
Paleta Creek	P01	108	432	1,696	40	0.6
	P02	258	1,504	5,106	79	1.8
	P03	177	808	2,864	51	1.2
	P04	311	1,329	4,825	101	3.7
	P05	464	2,170	7,541	751	3.9
	P06	428	2,110	7,745	122	2.8
	P07	401	1,870	7,024	114	4.2
	P08	342	2,870	7,329	80	3.2
	P09	24	108	357	10	0.3
	P10	196	1,326	3,846	72	5.8
	P11	417	5,540	17,016	369	21.5
	P12	444	3,470	9,078	129	9.8
	P13	99	645	2,054	53	3.2
	P14	514	2,810	7,964	196	16.6
	P15	400	5,440	14,717	374	34
	P16	539	3,940	11,330	192	22.1
	P17	556	4,440	13,486	189	14.2
	Mean	334	2,401	7,293	172	8.8
ERM		3,160	9,600	44,792	180	6
ERL		552	1,700	4,022	22.7	0.5

[1] Sum of naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene.
[2] Sum of fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[a]pyrene, dibenzo[a,h]anthracene
[3] Sum of 41 PCB congeners
Shaded values exceed ERM.
Source: SCCWRP and SPAWAR (2005)

Chollas Creek

The total PAH mean concentration at the Chollas Creek stations exceeded the reference station mean by a factor of 5. The highest concentrations were located in the inner channel at stations C12 and C13. Station C12 exceeded the ERM for total PAHs and 11 of 14 stations exceeded the ERL.

Total PCB mean concentration exceeded the reference station mean by a factor of 2.7. The highest concentration was found at station C02, near the mole pier. Eight (8) stations exceeded the ERM value for total PCBs and all of the stations exceeded the ERL.

Pesticide results for the Chollas Creek stations indicate that the total chlordane mean concentration exceeded the reference station mean concentration by 11 times. The inner channel station (C14) had the highest concentration of chlordane. All of the Chollas Creek stations exceeded the ERL for chlordane. Table F-25 presents the sediment chemistry for the mouth of Chollas Creek.

Table F-25. Sediment chemistry data for Chollas Creek site and reference stations

Area	Station	LMWPAH[1] µg/kg	HMWPAH[2] µg/kg	Total PAHs µg/kg	Total PCBs[3] µg/kg	Total Chlordane µg/kg
Reference	CP 2231	86	536	1,591	43	0.9
	CP 2238	17	103	288	12	0.2
	CP 2243	20	118	387	21	0.2
	CP 2433	56	415	1,166	27	0.6
	CP 2440	1,052	3,049	8,061	283	16.2
	CP 2441	236	1,210	3,208	34	0.8
	Mean	245	905	2,450	70	3.2
Chollas Creek	C01	326	2,184	7,105	190	29
	C02	341	2,050	7,094	422	31
	C03	623	2,660	9,260	320	37
	C04	266	1,787	5,510	145	20.9
	C05	298	1,913	6,385	234	36
	C06	367	2,306	7,482	190	29
	C07	130	772	2,089	60	4.6
	C08	116	775	2,233	53	7.9
	C09	3,048	6,020	16,512	154	20.3
	C10	332	2,560	7,983	202	21.7
	C11	120	1,013	2,755	74	10.4
	C12	7,475	36,060	65,672	167	30
	C13	2,007	11,600	24,882	255	89
	C14	1,212	5,194	15,433	212	119
	Mean	1,190	5,492	12,885	191	35
ERM		3,160	9,600	44,792	180	6
ERL		552	1,700	4,022	22.7	0.5

[1] Sum of naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene.
[2] Sum of fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[a]pyrene, dibenzo[a,h]anthracene
[3] Sum of 41 PCB congeners
Shaded values exceed ERM
Source: SCCWRP and SPAWAR (2005)

Switzer Creek

PAHs were detected in sediments at all of the Switzer Creek stations, and the total PAH mean concentration exceeded the reference mean concentration by a factor of 3.8. None of the samples exceeded the ERM or the ERL. Anderson et al. (2004) calculated a PAH quotient for each station that was compared with the 95 percent upper prediction limit (UPL) of the reference station PAH quotient. All stations, except for SWZ02, had PAH quotients exceeding the 95 percent UPL of the reference station PAH quotients, indicating that PAH contamination at these sites is likely site-specific.

PCBs were detected in the sediments at all Switzer Creek stations, and the total PCB mean concentration exceeded the reference mean concentration by a factor of 14. Two of the stations exceeded the ERM and all stations exceeded the ERL. Chlordanes were detected at three Switzer Creek stations: SWZ01, SWZ05, and SWZ06. Total chlordane at these three sites exceeded the ERM of 6.0 μg/kg dry weight. PCBs and chlordane were not detected at any of the reference stations, which indicates that PCBs and chlordane contamination at the mouth of Switzer Creek is likely site-specific.

Anderson et al. (2004) Sediment Quality Guideline Quotients (SQGQs) for all Switzer Creek stations and reported that all stations were in exceedance of the upper 95 percent prediction limit for the reference stations, indicating that these stations have elevated chemical mixtures relative to reference stations. Table F-26 presents the sediment chemistry data for the mouth of Switzer Creek.

Table F-26. Sediment chemistry data for Switzer Creek site and reference stations

Area	Station	Total PAHs µg/kg	Total PCBs µg/kg	Total Chlordane µg/kg
Reference	2229	200	15	1.5
	2238	14	15	1.5
	2243	55	15	1.5
	2433	136	15	1.5
	2435	78	15	1.5
	2441	57	15	1.5
	Mean	90	15	1.5
Switzer Creek	SWZ01	268	59	6.9
	SWZ02	147	109	1.5
	SWZ03	625	630	1.5
	SWZ04	383	209	1.5
	SWZ05	308	105	14.1
	SWZ06	315	177	12.9
	Mean	341	215	6.4
ERM		44,792	180	6
ERL		4,022	22.7	0.5

Shaded values exceed ERM
Source: Anderson et al. (2004)

F1.7.2 Sediment Toxicity

Paleta Creek

Toxicity results for the amphipod 10-day survival test using whole sediment indicated that samples from stations P01, P03, P05, P08, P10, P13, P15, P16, and P17 exhibited marginal toxicity (significant difference from control but greater than or equal to the threshold of 75 percent survival), whereas the station P11 sample exhibited toxic conditions (significant difference from control but less than the threshold of 75 percent survival.

Toxicity results for sea urchin embryos at the sediment-water interface indicated that stations P11, P15, P16, and P17 were toxic with percent embryo development at these stations (after correction for NH3) ranging from 10 to 47 percent (after outliers are removed). The threshold for the sea urchin development test was 59 percent. The toxicity to sea urchin embryos was negatively correlated with PAHs, PCBs, and chlordane.

Toxicity results for the sea urchin fertilization test using sediment porewater indicated that only samples from stations P01 and P02 exhibited toxicity (significant difference from control but < threshold of 88 percent fertilization). Table F-27 presents the toxicity test results for the mouth of Paleta Creek.

Table F-27. Sediment toxicity tests results for Paleta Creek site and reference stations

Station	Amphipod 10-day Survival Test – Whole Sediment		Sea Urchin Development Test – Sediment-Water Interface		Sea Urchin Fertilization Test – 100% Porewater	
	Mean	Sign. Diff. from Control	Mean	Sign. Diff. from Control	Mean	Sign. Diff. From Control
Control	94		100		82	
Reference Station						
CP2238	85	*	88		29	**
Paleta Creek Stations						
P01	90		80		58	**
P02	82	*	104		64	**
P03	92		Outlier		93	
P04	83	*	110		83	
P05	88		80		85	
P06	88		97		70	
P07	91		96		94	
P08	82	*	106		72	
P09	92		88		83	
P10	84	*	Outlier		91	
P11	47	**	47	**	88	
P12	88		54		95	
P13	79	*	100		82	
P14	86		66		96	
P15	80	*	27	**	97	
P16	79	*	10	**	97	
P17	84	*	47	**	98	

* = Marginal Toxicity (significant difference from control but ≥ threshold of 75% survival, 59% normal embryo development, or 88% successful fertilizations).
** = Toxic (significant difference from control but < threshold of 75% survival, 59% normal embryo development, or 88% successful fertilizations).
Source: SCCWRP and SPAWAR (2005)

Chollas Creek

Toxicity results for the amphipod 10-day survival test using whole sediment indicated that samples from stations C03, C05, C07, C08, C09, C11 and C13 exhibited marginal toxicity (significant difference from control but greater than or equal to the threshold of 75 percent survival), whereas the station C01, C02, C04, C06, C11 and C14 sample exhibited toxic conditions (significant difference from control but less than the threshold of 75 percent survival).

Toxicity results for sea urchin embryos at the sediment-water interface indicated that stations C09, C12, and C14 were toxic with percent development at these stations (after correction for NH_3) ranging from 24 to 33 percent (after outliers were removed). The threshold for the sea urchin development test was 59 percent. The toxicity to sea urchin embryos was negatively correlated with PAHs, PCBs, and chlordane.

Toxicity results for the sea urchin fertilization test using sediment porewater indicated that only samples from stations C12 and C13 exhibited toxicity (significant difference from control but < threshold of 88 percent fertilization). Table F-28 presents the toxicity test results for Chollas Creek.

Table F-28. Chollas Creek toxicity test results summary table

Station	Amphipod 10-day Survival Test – Whole Sediment		Sea Urchin Development Test – Sediment-Water Interface		Sea Urchin Fertilization Test – 100% Porewater	
	Mean	Sign. Diff. from Control	Mean	Sign. Diff. from Control	Mean	Sign. Diff. From Control
Control	99		100		36	
Reference Stations						
CP2231	75		Outlier		61	**
CP2243	83		106		91	
CP2433	83	*	116		93	
CP2440	94		99		79	**
CP2441	81	*	89		96	
Chollas Creek Stations						
C01	58	**	72		84	
C02	71	**	77		93	
C03	75	*	62	*	99	
C04	70	**	79		87	
C05	79	*	70		92	
C06	61	**	60		88	
C07	93	*	90		94	
C08	95	*	82		96	
C09	79	*	32	**	88	
C10	68	**	63	*	82	*
C11	90	*	77	*	92	
C12	91		24	**	75	**
C13	78	*	88		0	**
C14	53	**	33	**	86	

* = Marginal Toxicity (significant difference from control but ≥ threshold of 75% survival, 59% normal embryo development, or 88% successful fertilizations).
** = Toxic (significant difference from control but < threshold of 75% survival, 59% normal embryo development, or 88% successful fertilizations).
Source: SCCWRP and SPAWAR (2005)

Switzer Creek

Amphipod survival rates in sediment samples were statistically significantly different from the control. Two of the Switzer Creek stations (SWZ04, SWZ06) also exhibited survival rates less than the percent minimum significant difference, and were considered toxic. All six Switzer Creek stations exhibited amphipod survival rates less than the 95 percent lower prediction limit of the reference stations.

No samples were toxic to mussel larvae at the sediment-water interface. Percent normal surviving larvae at all stations were greater than the 95 percent lower prediction limit for the reference stations, indicating that the response of larvae to sediment-water interface exposure at most study site stations is similar to that at the reference stations.

No porewater samples were toxic when tested with the urchin fertilization test. Fertilization rates at all Switzer Creek stations were greater than the 95 percent lower prediction limit for the reference sites, indicating that the response of gametes to porewater at most study site stations is similar to that at the reference stations.
Table F-29 presents the Phase I toxicity data for the mouth of Switzer Creek.

Table F-29. Switzer Creek toxicity summary table

Station	Amphipod 10-day Survival Test – Whole Sediment		Mussel Larval Development Test – Sediment-Water Interface		Sea Urchin Fertilization Test – 100% Porewater	
	Mean	Sign. Diff. from Control	Mean	Sign. Diff. from Control	Mean	Sign. Diff. From Control
Control	98		85		74	
Reference Stations						
2229	99		89		84	
2238	87	*	86		75	
2243	94		78		70	
2433	93	*	65	*	68	
2435	95		55	*	75	
2441	96		68		63	*
Switzer Creek Stations						
SWZ01	73	*	74		94	*
SWZ02	76	*	66		95	*
SWZ03	84	*	86		93	*
SWZ04	69	**	67		91	*
SWZ05	73	*	82		94	*
SWZ06	70	**	80		82	*

* = Marginal Toxicity (significant difference from control but ≥ threshold of 74% survival, 68% normal larval development, or 65% successful fertilizations).
** = Toxic (significant difference from control but < threshold of 74% survival, 68% normal larval development, or 65% successful fertilizations).
Source: Anderson et al. (2004)

F1.7.3 Benthic Community

Paleta Creek

The species diversity values at the Paleta Creek stations were relatively high, ranging from 1.81 to 2.82. The Benthic Response Index (BRI) values for nine of these stations indicated at least a 50 percent loss of biodiversity (BRI level III), and a 25 – 50 percent loss of biodiversity (BRI level II) at six stations (Table F-30).

Table F-30. Benthic community measures for reference and Paleta Creek stations

Station	Abundance	Number of Taxa	Shannon-Wiener Diversity	Benthic Response Index Level
Reference Stations				
CP2231	6343	88	1.09	I
CP2243	691	41	2.34	III
CP2433	421	57	2.82	Reference
CP2440	918	66	2.88	Reference
CP2441	476	66	2.93	Reference
CP2238	419	32	2.56	III
Paleta Creek Stations				
P01	155	31	2.76	I
P02	125	22	2.47	I
P03	254	31	2.42	III
P04	210	24	2.26	II
P05	127	16	1.81	II
P06	70	15	2.09	III
P07	196	22	2.25	III
P08	773	33	2.21	II
P09	36	18	2.67	II
P10	255	26	2.50	III
P11	88	24	2.82	III
P12	304	36	2.69	II
P13	768	35	2.35	II
P14	487	36	2.42	III
P15	114	21	2.24	III
P16	153	19	2.06	III
P17	151	20	2.63	III

Source: SCCWRP and SPAWAR (2005)

Chollas Creek

The species diversity values at the Chollas Creek stations ranged from 0.44 to 2.67. The BRI values for nine of these stations indicated at least a 50 percent loss of biodiversity (BRI level III or IV), and a 25 – 50 percent loss of biodiversity (BRI level II) at four stations (Table F-31). One station, C11, had a BRI value characteristic of a reference community.

Table F-31. Benthic community summary table for Chollas Creek

Station	Abundance	Number of Taxa	Shannon-Wiener Diversity	Benthic Response Index Level
Reference Stations				
CP2231	6343	88	1.09	I
CP2243	691	41	2.34	III
CP2433	421	57	2.82	Reference
CP2440	918	66	2.88	Reference
CP2441	476	66	2.93	Reference
CP2238	419	32	2.56	III
Chollas Creek Stations				
C01	375	34	2.49	II
C02	154	32	2.47	II
C03	163	22	2.05	III
C04	471	29	2.44	III
C05	206	21	1.89	III
C06	301	32	2.63	II
C07	431	40	2.40	II
C08	20	6	1.16	III
C09	642	43	2.67	III
C10	314	30	2.46	III
C11	7	7	1.95	Reference
C12	34	14	2.27	III
C13	190	26	2.15	III
C14	553	10	0.44	IV

Source: SCCWRP and SPAWAR (2005)

Switzer Creek

Anderson et al. (2004) calculated 2 multi-metric indices of benthic community condition from the benthic data: 1) the Relative Benthic Index (RBI; Stephenson et al. 1994); and 2) the Benthic Response Index (BRI; Smith et al. 2001) developed by SCCWRP for Bight 98 (Table F-32). The RBI evaluates contaminant- and non-contaminant-related conditions and the BRI evaluates contaminant-related conditions. Indices from the impacted stations were also compared to the reference station 95 percent prediction limit (α = 0.05) to determine if the observed benthic community degradation was site-specific. Table F-32 provides the descriptions for the indices used in evaluating the benthic community data.

Table F-32. Indices used in evaluating benthic community data

Benthic Index Method	Calculated Index Value	Assessment of Habitat
Relative Benthic Index (RBI)	0.60 – 1.00	Undegraded
	0.31 – 0.59	Transitional
	0.00 – 0.30	Degraded
Benthic Response Index (BRI)	< 31	Reference
	31 – 42	Response Level I (least impacted)
	42 – 53	Response Level II
	53 – 73	Response Level III
	> 63	Response Level IV (most impacted)

Source: Anderson et al. (2004)

A number of Switzer Creek stations had slightly (BRI level I) to moderately impacted benthic community structure (level II) based on calculation of the BRI. Two stations, SW04 and reference station 2238, were categorized as response level III based on the BRI. No stations exceeded the 95 percent prediction limit based on the reference site distribution of BRI values.

Relative Benthic Index (RBI) calculations indicated that two of the Switzer Creek stations were degraded (SWZ01, SWZ02), three were transitional (SWZ04, SWZ05, SWZ06), and one was undegraded (SWZ03). The two degraded stations (SWZ01 and SWZ02) were two of the three stations where fines content exceeded 90 percent. The RBI for the five degraded and transitional stations was less than the lower 95 percent prediction limit for the reference sites, indicating that community degradation is site-specific. A summary of the benthic community measures for Switzer Creek is provided in Table F-33.

Table F-33. Benthic community measures for reference and Switzer Creek stations

Station	RBI assessment	Benthic Response Index Level
Reference stations		
2229	Undegraded	Reference
2238	Undegraded	III
2243	Undegraded	II
2433	Undegraded	I
2435	Undegraded	Reference
2441	Undegraded	Reference
Switzer Creek stations		
SWZ01	Degraded	II
SWZ02	Degraded	II
SWZ03	Undegraded	II
SWZ04	Transitional	III
SWZ05	Transitional	II
SWZ06	Transitional	I

Source: Anderson et al. (2004)

F1.7.4 Weight of Evidence

The primary beneficial use of concern is the impairment to health of benthic organisms, (Aquatic Life), focusing on invertebrates that live in the sediments. A potential for exposure and impact to fish and birds that prey on these benthic organisms (Aquatic Dependent Wildlife), as well as potential exposure to humans through fishing activities (Human Health) may occur. The multiple lines of evidence are used to assess the potential for impairment to each of these three beneficial uses.

The impairment for the aquatic life beneficial use was determined using the weight of evidence from the chemistry, toxicity, and benthic community measurements. These data were used to assign a level of impairment into three categories of “Likely”, “Possible”, or “Unlikely”. The area of likely impairment for aquatic life at the mouth of Paleta Creek was located in the inner channel of the estuary where four stations were classified as “likely” to be impaired (Figure F-12). The areas of likely impairment for aquatic life were the mouth of Chollas Creek at three locations mid-channel between the two piers and three stations in the back channel (Figure F-13). The areas of likely impairment for aquatic life at the mouth of Switzer Creek were stations SWZ01, SWZ02, SWZ04, and SWZ05. The other two stations (SWZ03 and SWZ06) were identified as possible impairment sites.

Potential for impairment to aquatic dependent wildlife at the Paleta and Chollas Creek mouths was categorized as unlikely for all receptors with respect to all contaminants of concern. Potential for human health impairment at the mouth of Paleta Creek was categorized as “unlikely” for all contaminants of concern except PCBs in fish and shellfish. The impairment related to PCBs was associated with the inner channel sites, as well as site P05, which is near the mole pier. The entire Paleta Creek mouth site was classified as possibly impaired for potential human health effects.

Potential for human health impairment at the mouth of Chollas Creek channel was categorized as “unlikely” for all for all contaminants of concern except PCBs in fish and shellfish. The impairment related to PCBs was associated with the inner channel sites, as well as site near the base of the NASSCO and Navy piers. The majority of the Chollas Creek channel site, except for the back channel area, was classified as possibly impaired for potential human health effects related to the consumption of PCBs in fish and shellfish.

Potential impairment to aquatic dependent wildlife and potential for human health impairment at the mouth of Switzer Creek were not categorized in the Phase I document. A weight of evidence analysis was conducted as part of the temporal assessment in the Phase II study by Anderson et al. (2005) and is discussed in section F1.8.1, below.

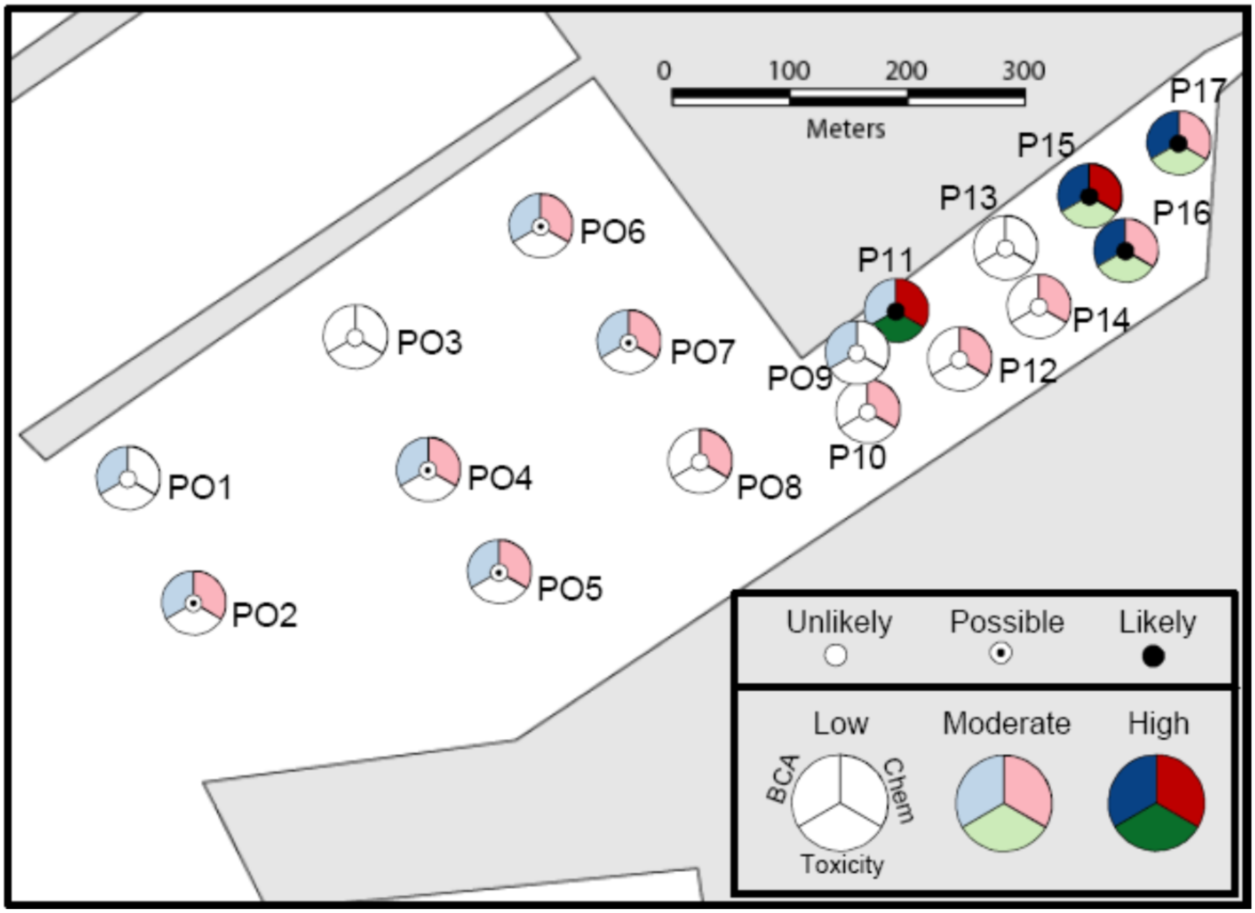

Figure F-12. Impairment at the mouth of Paleta Creek based on the weight of evidence analysis
Source: SCCWRP and SPAWAR (2005)

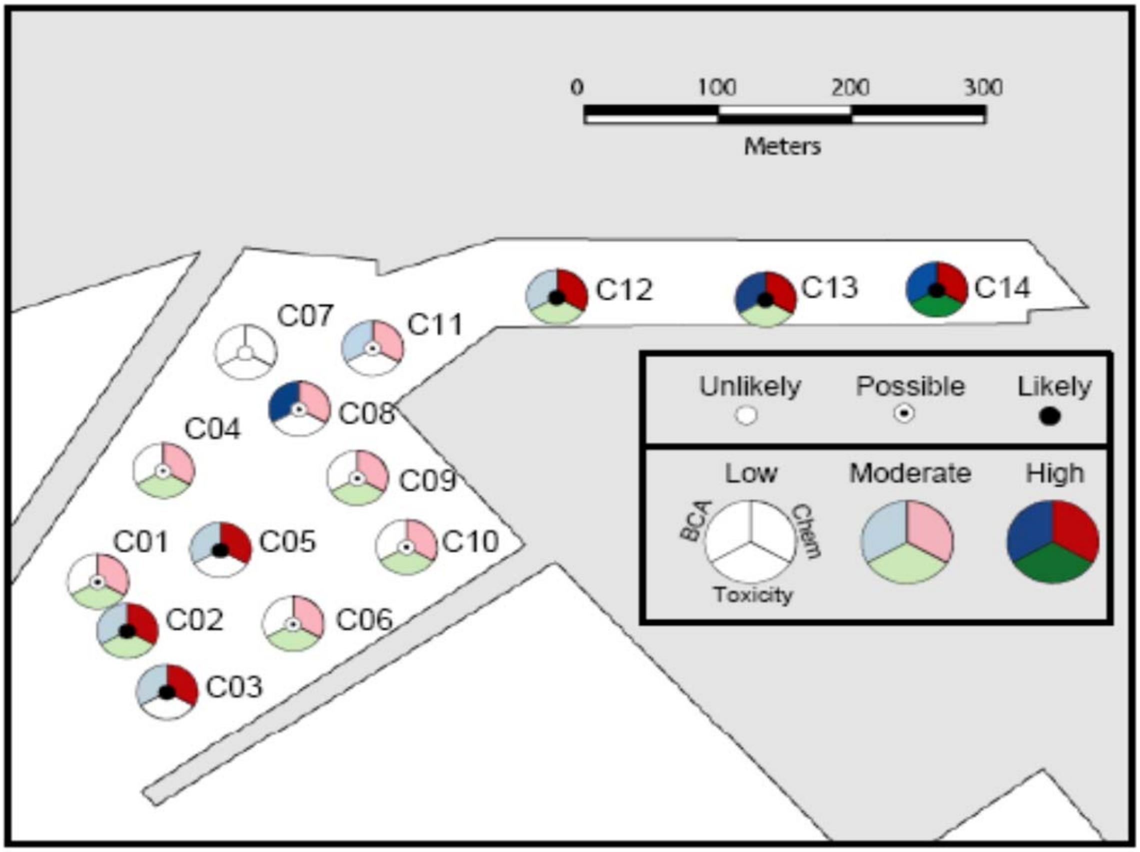

Figure F-13. Impairment at the mouth of Chollas Creek based on the weight of evidence analysis
Source: SCCWRP and SPAWAR (2005)

F1.7.5 Bioaccumulation

Bioaccumulation exposure experiments were conducted by exposing bivalve organisms (Macoma nasuta) to control, reference, Paleta Creek mouth site, and Chollas Creek mouth site sediments during a 28-day test period. The station bioaccumulation data were used to perform a screening level risk assessment for human health by estimating exposure for humans from the consumption of fish or shellfish. The findings of the spatial analysis are as follows:

- The entire Paleta site was classified as possibly impaired for potential human health effects related to the consumption of BAP and PCBs in fish and shellfish.

  From the station-by-station analysis, all of the seventeen Paleta stations were categorized as possibly impaired for both BAP and PCBs. Spatially, the highest magnitude of impairment related to BAP was found along the northern extent of the inner Creek area (P11, P13, P15 and P17). In general, the higher magnitude of impairment in the inner Creek area related to BAP corresponded with high levels in the sediment, as well as higher levels of TOC. The highest magnitude of impairment related to PCBs along the northern extent of the inner Creek area (P11, P13, P15 and P17) and at station (P05) near the Mole Pier. In general, the areas with higher magnitude of impairment related to PCBs corresponded with high levels in the sediment.

- The entire Chollas site was classified as possibly impaired for potential human health effects related to the consumption of benzo(a)pyrene (BAP) in fish and shellfish.

  From the station-by-station analysis, all of the fourteen Chollas stations were categorized as possibly impaired for BAP. Spatially, the highest magnitude of impairment related to BAP was found in the mid-inner Creek area (C12-C13) and near the base of Pier 1 (C09-C10). In general, the areas with higher magnitude of impairment related to BAP corresponded closely with high levels in the sediment, but were not strongly related to the distribution of TOC or fines.

- The majority of the Chollas site, excepting the inner Creek area, was classified as possibly impaired for potential human health effects related to the consumption of PCBs in fish and shellfish.

  From the station-by-station analysis, twelve of the fourteen were categorized as possibly impaired for PCBs. The highest magnitude of impairment related to PCBs was found near the base of the NASSCO pier (C07) and the end of Pier 1 (C02-C03), while the inner Creek area (C13-C14) had tissue concentrations below the tissue screening level (TSL). The higher bioaccumulation of PCBs at C07 appeared to be related to higher bioavailability associated with the low binding characteristics of this sediment. Higher bioaccumulation at C02-C03 appears to relate primarily to higher PCB concentrations in the sediment.

F1.8 Phase II Assessment of Chemistry, Toxicity, and Benthic Communities in Sediments at the Mouths of Paleta, Chollas, and Switzer Creeks

Phase II of the sediment quality assessments for Paleta, Chollas, and Switzer creeks included laboratory research to identify the causes of sediment toxicity using toxicity identification evaluation methods, assessment of the temporal patterns of chemistry, toxicity, and benthic community degradation, and an evaluation of possible sources of contaminants of concern.

Phase II results for Paleta, Chollas, and Switzer creeks are summarized in the following sections. The complete Phase II reports for Paleta and Chollas creeks are titled *Temporal Assessment of Chemistry, Toxicity, and Benthic Communities in Sediments at the Mouths of Chollas Creek and Paleta Creek, San Diego Bay* (Brown and Bay 2005) and *Sediment Toxicity Identification Evaluation for the Mouths of Chollas and Paleta Creek, San Diego* (Greenstein et al. 2005). The complete Phase II report for Switzer

Creek is titled *TMDL Sediment Quality Assessment Study at the B Street/Broadway Piers, Downtown Anchorage, and Switzer Creek, San Diego, Phase II Final Report* (Anderson et al. 2005).

F1.8.1 Temporal Assessments

Paleta and Chollas Creeks

The Phase II report, by Brown and Bay (2005), describes the temporal variability of sediment conditions near the mouths of Paleta and Chollas creeks, as well as the reference stations. Sediment samples were collected from two reference stations, two Chollas Creek stations (C10 and C14), and two Paleta Creek stations (P11 and P17) over five sampling events in 2001 and 2002.

Most **sediment chemistry** parameters were consistent over the five sampling periods at most stations. Much of the high variability was associated with chlordane measurements. There were a few instances where concentrations of PCBs had high variability. While there was high variability in a few instances, the variability was not consistently associated with any particular station or sampling event. The differences also did not appear to be related to season or rainfall.

Some indicators were found to be consistently above or below the 95 percent prediction limit for all five sampling events. Total PCBs and chlordane were consistently above the prediction limit at all Chollas and Paleta Creek stations.

Greater variability in the impairment classification was found at stations C10 and P11; the classification for these stations varied from unlikely to likely over time as a result of variations in the measures of biological impact (toxicity or benthic community composition).

Table F-34 presents a summary of the temporal sediment chemistry data collected for Phase II of the sediment assessment study for Paleta and Chollas creeks.

Table F-34. Organic contaminants in sediment samples from Paleta and Chollas creeks

Stations		Parameter (μg/kg)	July/August 2001	November 2001	February 2002	June 2002	October 2002
Reference	CP2243	Total PAHs	342	294	281	265	338
		Total PCBs	21	16	19	15	14
		γ - chlordane	0.11	0.36	0.28	0.61	ND
		α - chlordane	0.095	ND	ND	ND	ND
	CP2433	Total PAHs	1,029	616	561	473	751
		Total PCBs	27	17	16	19	14
		γ - chlordane	0.39	0.25	ND	0.38	ND
		α - chlordane	0.18	ND	ND	ND	ND
Paleta Creek	P11	Total PAHs	15,901	10,411	12,747	13,949	14,487
		Total PCBs	369	195	190	402	135
		γ - chlordane	14	9.2	7.7	19	7.2
		α - chlordane	7.5	1.6	1.3	4	ND
	P17	Total PAHs	12,053	11,097	11,089	35,966	20,050
		Total PCBs	189	238	265	223	199
		γ - chlordane	6.4	20	12	13	16
		α - chlordane	7.8	6.6	7.8	8.2	10
Chollas Creek	C10	Total PAHs	6,905	6,437	5,154	4,036	7,797
		Total PCBs	202	138	118	109	121
		γ - chlordane	13	8.7	9.9	4.9	ND
		α - chlordane	8.7	3.1	4.1	1.6	ND
	C14	Total PAHs	14,283	11,356	14,564	11,882	16,442
		Total PCBs	212	113	119	157	77
		γ - chlordane	65	31	44	31	31
		α - chlordane	54	14	16	26	34

ND = below method detection limit
Source: Brown and Bay (2005)

The weight of evidence (WOE) approach was applied to the temporal lines of evidence (LOE) data in the temporal study. The WOE Table F-35 is used here mainly to display results for the Toxicity and the Benthic Community sections of the Temporal Study.

Table F-35. Results of weight of evidence determination of aquatic life impairment for each sampling event

Station	Sampling Event	Chemistry	Toxicity	Benthos	Impairment
CP2243	July/August 2001	○	○	○	Unlikely
CP2243	November 2001	○	○	⊙	Unlikely
CP2243	February 2002	○	●	○	Unlikely
CP2243	June 2002	○	○	○	Unlikely
CP2243	October 2002	⊙	○	○	Unlikely
CP2433	July/August 2001	○	○	○	Unlikely
CP2433	November 2001	○	○	○	Unlikely
CP2433	February 2002	○	○	○	Unlikely
CP2433	June 2002	○	○	○	Unlikely
CP2433	October 2002	○	○	○	Unlikely
P11	July/August 2001	●	●	⊙	Likely
P11	November 2001	⊙	○	○	Unlikely
P11	February 2002	⊙	●	⊙	Likely
P11	June 2002	●	●	⊙	Likely
P11	October 2002	⊙	○	⊙	Possible
P17	July/August 2001	⊙	⊙	●	Likely
P17	November 2001	●	⊙	○	Likely
P17	February 2002	⊙	●	○	Possible
P17	June 2002	●	⊙	○	Likely
P17	October 2002	●	⊙	⊙	Likely
C10	July/August 2001	⊙	⊙	○	Possible
C10	November 2001	⊙	○	○	Unlikely
C10	February 2002	⊙	⊙	⊙	Likely
C10	June 2002	⊙	○	○	Unlikely
C10	October 2002	⊙	○	⊙	Possible
C14	July/August 2001	●	●	●	Likely

Station	Sampling Event	Chemistry	Toxicity	Benthos	Impairment
C14	November 2001	●	○	●	Likely
C14	February 2002	●	●	●	Likely
C14	June 2002	●	●	●	Likely
C14	October 2002	●	●	●	Likely

○ **No/Low impact from contaminants of concern relative to baseline.** For chemistry, there were no constituents that exceeded both the sediment quality guideline and prediction limit, and the SQGQ1 was either < 0.25, or < 95% prediction limit. For Benthos, the BRI < 42 and neither abundance, # taxa, nor diversity exceeded the prediction limit. For toxicity, none of the three tests (amphipod survival, sea urchin development, sea urchin fertilization) had significant toxicity or exceeded the prediction limit.

⦿ **Moderate impact.** For chemistry, the SQGQ1 exceeded the prediction limit, but was ≤ 1. Or, 1 – 5 constituents exceeded both the sediment quality guideline and prediction limit. For benthos, the BRI is both ≥ 42 and exceeded both the prediction limit. Or, either abundance, # taxa, or diversity exceeded the prediction limit. For toxicity, either amphipod survival, sea urchin development, or sea urchin fertilization was both significantly toxic and exceeded the 95% prediction limit.

● **High impact.** For chemistry, the SQGQ1 was both ≥1.0 and ≥ prediction limit. Or, more than 5 constituents exceeded both the sediment quality guideline and the prediction limit. For benthos, the BRI > 72. Or, the BRI was both > 52 and exceeded the prediction limit, and abundance, # taxa or diversity exceeded the prediction limit. For toxicity, the amphipod survival test had significant toxicity, exceeded the prediction limit, and had < 50% of the control survival. Or, both the sea urchin development and fertilization tests had significant toxicity, exceeded the prediction limits, and were < 50% control response. Or, both the amphipod survival test and one of the other tests had significant toxicity and exceeded the prediction limit.
Source: Brown and Bay (2005)

Most samples from the reference stations had chemistry values in the low impact category. Only one sampling event, from reference station CP2243 during October, exceeded both the 95% prediction limit and the PEL for this sample, which placed it in the Moderate category.

For Station C14, all samples were rated as high impact. The SQGQ1 for all five sampling events from Station C14 was >1.0, and exceeded the 95% prediction limit. Concentrations of zinc at Station C14 exceeded the ERM only in the February, June, and October samples. All sampling events for Station C10 were rated as moderate impact. Total chlordane exceeded the PEL and prediction limit for all five samples, while copper exceeded these criteria in the July sample.

The chemistry LOE category at Station P17 was in the high impact category during November, June and October samples, and in the moderate impact category for the August and February samples. Total chlordane exceeded the prediction limit and PEL during all five sampling events, while zinc exceeded the prediction limit and ERM in the October sample. Station P11 was rated high impact for the August and June samples, and rated moderate impact for the November, February, and October samples. Total chlordane exceeded the prediction limit PEL in all five sampling events, while Hg exceeded the prediction limit and ERM in the August and June samples.

Toxicity for Chollas (C) and Paleta Creek (P) mouths was measured using three methods: The amphipod survival test in sediment, sea urchin embryo development test at the sediment-water interface, and sea urchin fertilization porewater toxicity test. The toxicity section of the LOE combines results of all three toxicity measurements for each of four sample stations over five sample events. The station nearest Chollas Creek mouth had the worst rating. Station C14 registered a high impact station for toxicity in four of five sampling periods. The magnitude of amphipod toxicity was great enough in the February, June and October samples to categorize these events as high impact. Amphipod survival in the July sample from Station C14 was significantly different from the control and below the prediction level, but was not below 50%. This sample was classified as high impact because it also had poor sea urchin development (significantly different from the control and below the prediction limit).

Station C10 had the best toxicity results (low impact) of the four sites sampled, with three sampling periods rating as low impact and two periods rating as moderate impact. In the July sample, amphipod survival was both significantly different from the control and below the prediction limit. In the February sample from Station C10, sea urchin embryo development was both significantly different from the control, and below the prediction limit (Table F-35).

Station P17, which was nearest Paleta Creek mouth, ranked second best on toxicity results with four moderate impact ratings and only one high impact rating. The August and June samples were classified as moderate impact because sea urchin development was both significantly different from the control, and below the prediction limit in both of these samples. The November sample from Station P17 was classified as moderate impact because sea urchin fertilization was both significantly different from the control and below the prediction limit. The October sample had amphipod survival and sea urchin development that was significantly different from the control, and below the prediction limit. The February sample was classified as high impact due to the magnitude of amphipod toxicity.

Station P11, located mid-way down the channel, had high impact ratings for three sampling periods and two low impact ratings for two sampling periods. The magnitude of amphipod toxicity was great enough in the February and June samples for the high impact category. The August samples from P11 had amphipod survival and sea urchin embryo development that were both significantly different from the control and below the prediction limit.

November always had the best toxicity ratings (3 low impact and 1 moderate impact) at each station, with October having good ratings (2 low impact and 1 moderate impact), except at Station C14. In contrast, February always had the worst ratings for each station (3 high impact and 1 moderate impact) (Table F-35).

For the **Benthic community analysis,** the Benthic Response Index (BRI) was used to determine the biotic integrity of a station. A BRI < 42 is considered low impact; > 72 is considered a high impact. For details on classifying for LOE, see the key below Table F-35). Station CP2243 had one sample from June that fell into the marginal category. All other reference stations were categorized as low impact. This station also was the only reference station to have a moderate impact category rating for the LOE rather than a low category rating.

All the samples from Station C10 and C14 were within or exceeded the marginal category. BRI values at Station C10 ranged from 44 in October samples to 56 in the August sample, placing them all in the BRI marginal category. Abundance and # taxa results are much lower for February and October than other times at Station C10. After analysis of all the benthic community measures for the LOE analysis, February and October samples are categorized as marginal for Station C10 and the remaining samples are categorized as low impact.

For Station C14, BRI values ranged from 62 for the November sample to 83 in the July sample. Four of the five stations at C14 had BRI values that fell in the BRI high impact category. While the November sample had a moderate impact BRI score, the BRI value still exceeded prediction limits, and the sample also had species diversity and # taxa values below the prediction limit; which thereby placed it into the high impact LOE category as well.

For Station P11 and P17, all samples fell within the BRI marginal category. BRI values for Station P11 ranged from 43 in the October sample to 55 in the August sample. Four of five samples at Station P11 were in the LOE moderate impact category. The November P11 sample was in the low impact category due to higher abundance and # taxa scores.

For Station P17, BRI values ranged from 47 in the February sample to 65 in the August sample (the marginal BRI category). For the LOE ranking, November, February, and June samples were placed in the low impact category due to high abundance and # taxa values. The October sample fell into the LOE moderate impact category, and the August sample was in the high impact category. Both October and August P17 samples exceeded the prediction limits, with August samples having obviously lower abundance and # taxa values.

The **weight of evidence** results are based on the chemistry, toxicity and benthic community results (Table F-35). Unlikely impairment was indicated for all of the reference stations. Station C14, nearest Chollas Creek mouth, was Likely impaired according to all months sampled. Station C10 had variable conditions with ratings ranging from Unlikely to Possible with one Likely impaired in February. Station P17 was Likely impaired with four Likely ratings and one possible rating in February. Station P11 had variable conditions (although in worse condition than Station C10) with three sample months Likely impaired, one Unlikely, and one Possibly impaired. Thus, the changes of the LOE and WOE categories across seasons for each creek mouth indicate vast differences across seasons in environmental conditions at those less impacted locations.

The extreme environmental conditions cause the higher mortality rates seen in the toxicity analyses and the lower abundances and # species seen in the benthic community analyses, whereas under more normal conditions, the benthic communities may or may not have time to recover before the next extreme event. A successful recovery event is dependent upon the amount of time until the next extreme event, and the length and timing of the life cycle of the organisms in the community.

Switzer Creek

The Phase II report examined temporal variability of chemical contamination of sediments and associated biological effects at the mouth of Switzer Creek and at reference stations. Sediment samples were collected from three Switzer Creek stations (SWZ01, SWZ02, and SWZ04) and five reference stations over three sampling events in 2004. The locations of the sample locations are shown in Figure F-14.

Figure F-14. Switzer Creek Phase II study area with sample locations

Based on measures of **sediment chemistry** and **toxicity** in the Phase II study (Anderson et al. 2005), the greatest impacts to aquatic-dependent life were observed in samples collected in February 2004. Less severe impacts were observed in the August and October sampling periods. These data imply that greater impacts occur during the wet season than in the dry season. These results suggest greater impacts may be associated with seasonal storm water inputs, but more detailed analyses of contaminant loadings are required.

Switzer Creek sediments were highly contaminated by chlordane in February, and station SWZ01 was also contaminated by relatively high concentrations of total PCBs. Concentrations of PAHs were also highest in February. Based on results of two toxicity tests, the highest magnitude of toxicity was observed in Switzer Creek sediment in February 2004. In addition, Switzer Creek sediments had impacted benthic communities. Table F-36 presents the Phase II temporal sediment chemistry data for Switzer Creek.

Table F-36. Switzer Creek temporal sediment chemistry data

Stations		Parameters	Units	February 2004	August 2004	October 2004	ERM	ERL
Reference	2229	Total PAHs	µg/kg	581	105	233	44,792	4,022
		Total PCBs	µg/kg	33	33	44	180	22.7
		Chlordane	µg/kg	3	3	3	6	0.5
	2238	Total PAHs	µg/kg	155	174	37	44,792	4,022
		Total PCBs	µg/kg	33	33	33	180	22.7
		Chlordane	µg/kg	3	3	3	6	0.5
	2243	Total PAHs	µg/kg	161	109	42	44,792	4,022
		Total PCBs	µg/kg	33	33	33	180	22.7
		Chlordane	µg/kg	3	3	3	6	0.5
	2433	Total PAHs	µg/kg	355	2,900	134	44,792	4,022
		Total PCBs	µg/kg	33	33	33	180	22.7
		Chlordane	µg/kg	3	3	3	6	0.5
	2441	Total PAHs	µg/kg	679	181	624	44,792	4,022
		Total PCBs	µg/kg	33	33	33	180	22.7
		Chlordane	µg/kg	3	3	3	6	0.5
Switzer Creek	SWZ01	Total PAHs	µg/kg	30,911	105	4,130	44,792	4,022
		Total PCBs	µg/kg	536[a]	42	33	180	22.7
		Chlordane	µg/kg	80[b]	7.9[b]	19[b]	6	0.5
	SWZ02	Total PAHs	µg/kg	13,721	105	3,420	44,792	4,022
		Total PCBs	µg/kg	334	46	33	180	22.7
		Chlordane	µg/kg	65[b]	14[b]	3	6	0.5
	SWZ04	Total PAHs	µg/kg	9,258	105	3,570	44,792	4,022
		Total PCBs	µg/kg	176	49	179	180	22.7
		Chlordane	µg/kg	21[b]	11[b]	18[b]	6	0.5

[a] Exceeds consensus based guideline value of 400 µg/kg and 95% upper prediction limit.
[b] Exceeds probably effects limit of 4.77 µg/kg and 95% upper prediction limit.
Source: Anderson et al. (2005)

Sediments for **toxicity** testing from the Switzer Creek mouth were highly toxic to both test species in February 2004. Amphipod survival was 0%, 2%, and 5% in samples from SWZ01, SWZ02, and SWZ04, respectively. Samples from SWZ01, and SWZ02 were almost completely toxic to sea urchin sperm during this period. Based on the LOE, all Switzer Creek stations were categorized as having high sediment toxicity in February. Switzer Creek mouth stations were categorized as having high sediment toxicity in February. Switzer Creek mouth sediments continued to be toxic to amphipods in August, but of the three stations, only SWZ04 (30% survival) exceeded the 95% LPL. None of the stations were toxicity to sea urchin fertilization during this time. Station SWZ04 was categorized as having low toxicity based on the LOE. No significant toxicity was observed using either protocol in any Switzer Creek mouth samples collected in October. All three stations were categorized as having low toxicity during October.

For the **benthic community analysis,** the three Switzer creek mouth station all had high BRI scores and all were classified as high impact sites, meaning there was community function loss. There were low number of species at each of the three stations, and few crustaceans. Although some mollusks were present, these tended to be species with higher pollution tolerance scores. The metrics for number of species, and Shannon-Weiner diversity were lower than the 95% LPL based on reference conditions (except for the Shannon-Weiner at SW02). In addition, the species assemblages at the Switzer Creek stations were dominated by pollution tolerant polychaete species. Based on the LOE criteria for benthic communities, all three Switzer Creek mouth stations fell into the high impact category.

Weight of evidence results at stations with Likely impairment include February samples from SWZ01, SWZ02, and SWZ04, as well as the August SWZ04 sample. All of the other Switzer Creek mouth samples were classified as Possibly impaired. All of the reference station samples fell into the Unlikely impaired category.

F1.8.2 Toxicity Identification Evaluation (TIE) Assessment

Paleta and Chollas Creeks

In this study, toxicity identification evaluation (TIE) methods were applied samples from stations that had shown toxicity during the Phase I Sediment Assessment Study and the Temporal Assessment. Three rounds of TIE testing were performed: Phase I samples (CP2433, C01, and C14) taken in July 2001, Temporal Assessment samples (CP2433, P11, P17, C10, and C14) taken in October 2002, and a sample set (CP2433, P11, and C13) collected in April 2004 for this study. The sediment concentration sample results for the April 2004 samples are presented in Table F-37. See tables in sections F1.7 and F1.8.1 for the corresponding data sets.

Table F-37. Sediment concentrations of the Chollas and Paleta Creek TIE Study for samples collected in April 2004

Station	Total PAHs μg/kg	Total PCBs μg/kg	Total Chlordane μg/kg
CP 2433	183	0[a]	0[a]
P11	3,023	20	4.8
C13	2,250	0[a]	11.2
ERM	44,792	180	6
ERL	4,022	22.7	0.5

[a] Non-detects were given the value 0 to calculate the total PCBs and total chlordane.

The TIE process applied to the sediment samples was able to identify several candidate chemical groups that had the greatest association with sediment toxicity at the Paleta, Chollas, and Switzer sites. While the specific contaminants responsible for toxicity could not be confirmed with the data available, some of the conclusions evident from the results from the Phase II report (Greenstein et al. 2005) are as follows:

- **Most of the toxicity to amphipods is associated with organic compounds** Treatment of the sediment with carbon particles (coconut charcoal) removed toxicity in most cases, while treatment to reduce metal exposure was usually ineffective. In addition, statistical correlations were strongest between several types of organic chemicals and toxicity. Chemical analyses also indicated that the bioavailability of divalent metal contaminants in sediment and pore water was very low.

- **Chlordane is a probable cause of sediment toxicity at the Chollas site** Chlordane concentration was highly correlated with sediment toxicity. The concentration of chlordane at station C14, near the mouth of Chollas Creek was higher than most other locations in southern California. Data from other field studies shows that chlordane concentrations higher than those measured at C14 are almost always toxic.

- **PAHs are a probable cause of sediment toxicity at the Chollas and Paleta sites** Calculations based on equilibrium partitioning theory indicate that PAH exposure from sediment contact is likely to result in chronic toxicity at the most contaminated sites from the Paleta study area. PAH concentrations from the Chollas site are lower and below the toxicity threshold, but these concentrations are still greater than most other locations in southern California.

- **PCBs are unlikely to be a probable cause of direct sediment toxicity at the Chollas and Paleta sites**
  Data from other laboratory and field studies indicate that the measured concentrations of PCBs at the study sites are several orders of magnitude lower than the levels associated with direct toxicity from sediment exposure. The significant correlations with toxicity found for these compounds are likely to be coincidental, probably the result of similar sources of loading with those contaminants causing the toxicity.

- **Sediment toxicity may be due to a varying mixture of measured and unmeasured contaminants**
  Patterns of toxicity differed between the Chollas and Paleta sites and there were inconsistent relationships between the sediment chemistry and toxicity results. These results suggest that there is no simple single cause of sediment toxicity. Some of this variability may be due to site variability; sediment grain size and TOC varied throughout the study sites and multiple sources of contaminants were present. Additional unmeasured contaminants may also be responsible for a portion of the toxicity; the standard chemical analyte list did not include potential toxicants such as organotins and pesticides in current use.

Switzer Creek

Two lines of evidence suggest that organic contaminants are the cause of toxicity in Switzer Creek sediments (Anderson et al. 2005). First, amphipod mortality was highly correlated with chlordane and PCBs in San Diego Bay sediments. In addition, amphipod mortality was weakly correlated with mixtures of contaminants in these samples. These results were corroborated by the solid-phase and elutriate TIEs, which showed that treatments that reduce bioavailabilty of organic chemicals significantly reduced amphipod mortality in SWZ01 sediment. Based on the chemistry of these samples, chlordane is a likely CoC. Chlordane was also identified as a primary CoC in this study area in previous BPTCP studies (Fairey et al. 1996).

In summary, organic chemicals are the likely cause of toxicity to amphipods at the mouth of Switzer Creek (Anderson et al. 2005). Amphipod mortality was more highly correlated with total chlordane concentrations than any other chemical constituent. Taken as a weight-of-evidence, the results suggest toxicity of Switzer Creek sediment was likely due to mixtures of organic chemicals containing high concentrations of chlordane.

F2. Storm Water Quality Data

This section summarizes the storm water data for Switzer, Chollas, and Paleta creeks for the listed toxic pollutants.

F2.1 Tenth Avenue Marine Terminal Storm Water Data

The Tenth Avenue Marine Terminal facility (TAMT) discharges industrial storm water from three discharge points around the facility. Eight storm water outfalls discharge to the subsurface Switzer Creek storm drain that terminates at the mouth area. Two sample sites (Sites 2 and 3) are located on the branch of the storm water conveyance that leads to the Switzer Creek mouth discharge point. The industrial storm water permit for TAMT does not require sampling for PAHs, PCBs, or chlordane, but it does require sampling for oil & grease, Total Petroleum Hydrocarbons (TPHs), and Total Recoverable Petroleum Hydrocarbons (TRPHs). Table F-38 and F-39 presents the storm water sample results for these parameters.

While PAHs would be only a portion of the oil & grease and TPHs found in the sample, the measurements would still provide us with an indication of whether PAHs were present. The Basin Plan limit for oil & grease is 15 mg/l in water. Samples were collected once or twice per year from 1994 thru 2002. The oil & grease limit was exceeded only once at Site 2 in 1994, and only once at Site 3 in 2002 with a high value of 45 mg/l. The oil & grease concentrations ranged from <1.0 mg/l to 19 mg/l at Site 2, and 1.0 mg/l to 9.4 mg/l and to 45.0 mg/l at Site 3. Oil & grease and TPH/ TRPH concentrations do not appear to be very high at this site in the water column most of the time. If these constituents can be used as a surrogate for PAHs then the sample results do indicate that TAMT is most likely a minor source of PAHs to Switzer Creek mouth.

In the 2005-2006 Annual Report for Industrial Storm Water Discharges for the TAMT facility (SDUPD 2006), samples were collected for 16 PAHs, 7 PCB Aroclors, and 19 forms of pesticides (including chlordane) at Site C on February 28, 2006 and at Site B on April 21,2006. All sample results were below the reporting limit (Table F-40).

Table F-38. Chemical concentrations in storm water measured at Tenth Avenue Marine Terminal Site #2 from 1994 to 2003 and Site B from 2004 to 2006

Dates	Total Petroleum Hydrocarbons – gas	Total Petroleum Hydrocarbons – diesel	Total Recoverable Petroleum Hydrocarbons	Oil & Grease
3/07/1994	•	•	•	< 1.25
11/10/1994	•	•	18.0	19.0
1/04/1995	•	•	•	< 1.0
1/31/1996	ND	ND	1.6	2.3
10/30/1996	•	•	1.5	•
1/23/1997	ND	•	ND	1.0
11/10/1997	ND	•	3.0	3.0
1/09/1998	ND	ND	8.0	9.0
11/09/1998	ND	•	ND	8.4
1/20/1999	ND	•	2.5	10.0
2/23/2000	ND	•	ND	6.2
4/17/2000	ND	•	ND	1.2
10/26/2000	ND	•	ND	6.0
1/08/2001	NS	NS	NS	NS
2/23/2001	NS	NS	NS	NS
11/29/2002	NS	NS	NS	NS
2/17/2002	NS	NS	NS	NS
12/16/2002	ND	•	ND	ND
3/15/2003	•	•	•	•
12/04/2004	•	ND	ND	0.64
1/07/2005	•	ND	1.6	2.1
10/17/2005	•	•	1.3	46.0
2/28/2006	•	•	•	•
4/04/2006	•	< 0.5	< 0.5	4.0

ND = Chemical not detected
NS = Sample efforts attempted, but no samples were collected
• = Chemical not sampled during this sampling effort
Source: SDUPD (2002, 2003, 2005, 2006)

Table F-39. Chemical concentrations in storm water measured at Tenth Avenue Marine Terminal Site #3 from 1994 to 2003 and Site C from 2004 to 2006

Dates	Total Petroleum Hydrocarbons – gas mg/l	Total Petroleum Hydrocarbons – diesel mg/l	Total Recoverable Petroleum Hydrocarbons mg/l	Oil & Grease mg/l
11/10/1994	•	•	< 5.0	< 5.0
1/04/1995	•	•	1.0	1.0
1/31/1996	ND	ND	1.4	2.5
10/30/1996	•	•	0.6	•
1/23/1997	ND	•	2.9	4.6
11/10/1997	ND	ND	5.0	6.0
1/09/1998	ND	ND	4.0	4.0
11/09/1998	ND	•	4.0	6.0
1/20/1999	ND	•	2.6	9.4
2/23/2000	NS	•	NS	NS
4/17/2000	NS	•	NS	NS
10/26/2000	NS	•	NS	NS
1/08/2001	ND	•	ND	7.0
2/23/2001	ND	•	ND	1.0
11/29/2002	NS	•	NS	NS
2/17/2002	ND	•	1.0	45.0
12/16/2002	•	•	•	•
3/15/2003	•	•	•	•
12/04/2004	•	ND	ND	ND
1/07/2005	•	ND	1.1	ND
10/17/2005	•	•	1.3	18.0
2/28/2006	•	•	0.5	7.0

ND = Chemical not detected
NS = Sample efforts attempted, but no samples were collected
• = Chemical not sampled during this sampling effort
Source: SDUPD (2002, 2003, 2005, 2006)

Table F-40. Organic chemical concentrations in storm water measured at Tenth Avenue Marine Terminal Site in 2006

Analyte	Site B April 4, 2006 µg/L	Site C February 28,2006 µg/L
Chlordane	< 5	< 5
Naphthalene	< 10	< 10
Acenaphthylene	< 10	< 10
Acenaphthene	< 10	< 10
Fluorene	< 10	< 10
Phenanthrene	< 10	< 10
Anthracene	< 10	< 10
Fluoranthene	< 10	< 10
Pyrene	< 10	< 10
Chrysene	< 10	< 10
Benzo(a)anthracene	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10
Benzo(a)pyrene	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10
Benzo(g,h,i)perylene	< 10	< 10
Aroclor – 1016	< 0.65	< 0.65
Aroclor – 1221	< 1.0	< 1.0
Aroclor – 1232	< 0.65	< 0.65
Aroclor – 1242	< 0.65	< 0.65
Aroclor – 1248	< 0.65	< 0.65
Aroclor – 1254	< 0.65	< 0.65
Aroclor – 1260	< 0.65	< 0.65

Source: SDUPD (2006)

F2.2 U.S. Navy Storm Water Data

The U.S. Navy conducts storm water monitoring for PAHs at Naval Base San Diego as required by their NPDES permit. The PAH monitoring results for the area at the Paleta Creek mouth are presented in Table F-41 and show that contaminants are found in the Navy's storm water discharge. Benzo(a)pyrene exceeds the California Toxics Rule (CTR) water quality objective of 0.00017 µg/L for Human Health Water & Organism.

Table F-41. Navy storm water monitoring data for Paleta Creek storm drain outfalls (1994 – 2000)

Pollutant	Arithmetic Mean Concentration (µg/L)	Number of Records	Standard Deviation	Range (µg/L)	Sample Dates	Number of Non-Detects
Acenapthene	5.7	7	4	1.7 – 10	1994-2000	5
Benzo(a)pyrene	1.6	2	-	1.6	2000	2
Chrysene	5.1	5	5	1.4 – 11	1996-2000	3
Fluoranthene	32.3	20	58	1.8 – 28	1995-2000	6
Fluorene	10.6	9	9	1.8 – 28	1995-2000	6
Phenanthrene	77.1	4	149	1.4 – 400	1994-2000	3
Pyrene	21.6	19	40	1.6 - 160	1994-2000	5

Source: U.S. Navy (2000)

Three storm events in the Paleta Creek watershed sampled for total PAHs produced event mean concentrations (EMCs) of 7,302 ng/L, 4,052 ng/L, and 592 ng/L (Chadwick et al. 1999). One storm that was sampled for total chlordane produced an EMC of 6.3 ng/L and when sampled for total PCBs produced an EMC of 59.0 ng/L (Chadwick et al. 1999).

F2.3 Storm Water Plume Study

Katz et al. (2003) collected water quality samples during a single storm event on February 12-14, 2001 at the mouths of Chollas and Paleta creeks. The Katz et al. (2003) study included simultaneous measurement of upstream EMCs of a suite of contaminants (stations CUP and PUP), time-weighted composite sampling and contaminant analysis of downstream Naval Base San Diego outfalls entering the creeks adjacent to the bay (stations CNAV and PNAV), and real-time continuous measures of hydrography and discrete contaminant sampling in the receiving water (stations C1 – C3 and P1 – P3). The contaminants included in the study were metals, total PAHS, pesticides, and total PCBs (note that the metals results are not discussed in this TMDL document). Receiving water measurements were made before, during, and after the storm to assess the spatial and temporal impacts of the storm water plumes.

Plume development in San Diego Bay was observed outside both creeks after the storm. All contaminants measured in both plumes showed a strong gradient out from the creek mouths to the end of the piers. Contaminant concentrations measured in the plume were generally highest during peak flow. In most cases concentrations measured at the end of the piers during and after the storm did not exceed levels measured at the mouths of the creeks prior to the storm, which indicates that a gradient may exist under non-storm conditions.

Chlordane showed the largest concentration increase above the initial concentrations in the bay. All organics exceeded the water quality criteria in the plume during the storm. Note that chlordane was above its water quality criteria prior to the storm as well. The highest levels were usually observed at the innermost station off each creek.

Chlordane had a strong positive correlation (>0.8 R^2) with TSS (Katz et al. 2003). The storm water data collected during this study are presented in Table F-42.

Table F-42. Storm water data collected in plumes at the mouths of Chollas and Paleta Creeks (February 2001)

Sample	Total PAHs (ng/L)	Chlordane (ng/L)	Total PCBs (ng/L)	TSS (ng/L)
Chollas Creek				
C1Pre	239	0.787	<MDL	1.78
C1Dur	1,252	28.8	1.9	564
C2Dur	1,021	20.2	6.3	166
C3Dur	68.6	0.341	2.8	1.46
C1Aft	2,270	23.3	14.1	89.3
C2Aft	140.9	0.557	2.2	3.87
C3Aft	79.3	0.172	0.57	3.75
CNAV	1,471	8.8	5.1	22.0
CUP	1,500	34.2	37.7	139
Paleta Creek				
P1Pre	93.5	0.423	<MDL	0.933
P1Dur	781	10.6	<MDL	48
P2Dur	128	0.494	1.496	1.35
P3Dur	117	0.2	2.5	1.14
P1Aft	750	3.34	1	6.44
P2Aft	790	3.26	10.6	11.33
P3Aft	145	0.718	4.583	3.33
PNAV	1,401	9.3	84.45	60.8
PUP	2,055	38.6	52.18	197

MDL = method detection limit
Source: Katz et al. (2003)

F2.4 Phase II Storm Water Data

As part of the Phase II portion of this TMDL study, *Monitoring and Modeling of Chollas, Paleta, and Switzer Creeks* (Appendix C-1: Schiff and Carter 2007) provided monitoring results of storm water sampling during the winter of 2005-2006 (wet season). Samples were collected at locations above tidal influence. PAHs and some pesticides were found in measurable amounts. Paleta and Chollas creeks had the greatest flow-weighted average for PAHs and Switzer Creek had the greatest flow-weighted average for chlordane. No detectable measurements of PCBs or lindane were made in any sample from any of the watersheds. The flow weighted mean storm water data are presented in

Table F-43. No single storm generated the greatest concentrations and no correlations between rainfall volumes, intensity, or durations were observed.

When TSS normalized storm water concentrations and sediment concentrations are compared for PAHs, concentrations from the watershed are, in many cases, higher than those found in the estuary sediments (Figures F-15 and F-16). These results indicate that the watershed is a source of loading to the Paleta Creek mouth. Note that this same analysis was not performed for Switzer Creek. Also note that PCBs and chlordane cannot be compared in this manner. Chlordane concentrations in the storm water samples were compared to the California Toxics Rule (CTR) values for freshwater with chlordane concentrations exceeding this value.

Table F-43. Seasonal flow weighted mean storm water data for organics for Chollas, Paleta, and Switzer Creeks

Pollutant (ng/L)	Switzer Creek[a,b]	Chollas Creek (south)[a,b]	Chollas Creek (north)[a,b]	Paleta Creek[a,b]
Total PCBs	0.50 ± 0.00	0.50 ± 0.00	0.50 ± 0.00	0.50 ± 0.00
Total PAHs	535.7 ± 539.1	387.2 ± 159.7	1,264.6 ± 337.2	851.8 ± 337.2
Total chlordane[c]	47.27 ± 42.05	11.56 ± 6.93	39.69 ± 0.00	40.49 ± 0.00
Lindane	0.50 ± 0.00	0.50 ± 0.00	0.50 ± 0.00	0.50 ± 0.00

[a] Data presented with ± 95% confidence intervals
[b] Data collected during 3 storm events during the wet season in 2005-2006
[c] CTR value for criterion continuous concentration is 4.3 ng/L (U.S. EPA 2000b)
Source: Schiff and Carter (2007)

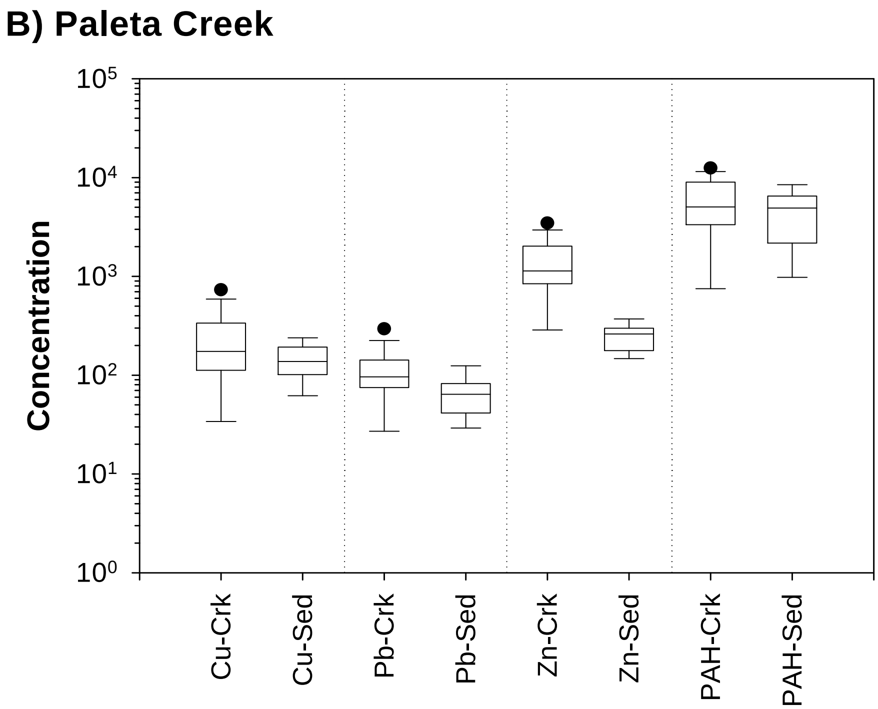

Figure F-15. Comparisons of TSS normalized storm water concentrations (crk) and sediment concentrations (sed) at the mouth of Paleta Creek
Source: Schiff and Carter (2007)

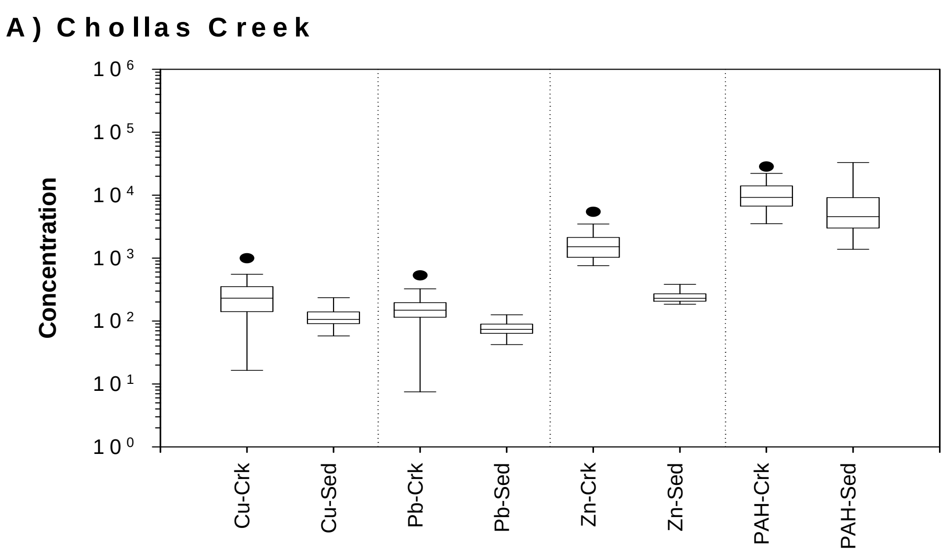

Figure F-16. Comparison of TSS normalized storm water concentrations (crk) and sediment (sed) concentrations at the mouth of Chollas Creek
Source: Schiff and Carter (2007)

F3. Water Quality Data of Impaired San Diego Bay Shoreline Areas

There is no information on the concentrations of organic pollutants in the waters at the mouth of Switzer Creek and very little information for the mouths of Chollas and Paleta creeks. The only water column data available at the mouths of the creeks are some PAH data collected by the U.S. Navy in 1997.

Water quality measurements were made throughout San Diego Bay in 1997 as part of the Navy's effort to assess current environmental conditions in the bay (Katz 1998). Water quality measurements focused on PAHs and copper. Discrete seawater samples were collected during two dry-weather surveys in July 16 and November 4, 1997. Several stations were sampled. Two of the stations were at the mouths of Chollas Creek (SD805) and Paleta Creek (SD807). Total PAH data from the two sampling dates are presented in Table F-44.

Table F-44. Total PAH concentrations at the mouths of Chollas and Paleta creeks

Station	July 16, 1997	November 4, 1997
	Total PAHs (ng/L)	Total PAHs (ng/L)
SDB05 – Chollas Creek	160	NA
SDB07 – Paleta Creek	120	72

Source: Katz (1998)

The highest PAH concentrations in the bay were observed at the four stations at the Naval Base San Diego (including the Chollas and Paleta Creek stations – SDB05 and SDB07). While total PAHs were lower on the second round of sampling in November, the Naval Base San Diego sites remained elevated in the November sampling compared to the other sampling locations in the bay (Katz 1998). PAH anaylte fingerprinting characterized the seawater samples as predominantly weathered creosote.