EXECUTIVE SUMMARY

A sampling and analysis program was conducted at Palos Verdes Shelf (PV Shelf), Los Angeles County, California, in support of monitored natural recovery (MNR), a component of the interim remedy set forth in EPA's 2009 Interim Record of Decision (IROD) for PV Shelf. PV Shelf is Operable Unit (OU) 5 of the Montrose Chemical Company Superfund Site, located in Los Angeles, California.

Background

Montrose OU 5 addresses risks to human health and the environment related to a bed of contaminated solids (sediment) on PV Shelf off the coast of the Pacific Ocean in southern California. In regions south of Los Angeles through the 1950s and 1960s, chemical producers (notably the DDT producer Montrose), discharged industrial wastes to the sanitary sewer system operated by the Sanitation Districts of Los Angeles County (Sanitation Districts). As a result, wastewater contaminated with DDTs and PCBs reached the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) in Carson, California. The contaminants were transported in the treated wastewater stream (JWPCP effluent) through tunnels under the Palos Verdes Hills to the JWPCP ocean outfall system, and were released to the ocean through the outfall diffusers. The diffusers are located about 2 kilometers (km) offshore, in water depths of about 60 meters (m). Suspended solids emitted from the diffusers formed a bed of "effluent affected" (EA) sediment on PV Shelf. The EA bed is contaminated with DDTs and PCBs. It is encountered at water depths of about 40 m to more than 100 m, and it extends along PV Shelf, parallel to the shore, for about 16 km. The DDTs have spread through the environment and impacted marine animals including fish and birds. DDTs have not been detected in the JWPCP waste stream since 2002, and PCBs have not been detected since 1985. However, these persistent substances remain as chemicals of concern (COCs) for Montrose OU 5.

Interim Record of Decision

In addition to MNR, the IROD set forth two other components of the interim remedy for Montrose OU 5: (1) continuation of the PV Shelf Institutional Controls (ICs) program that includes: public outreach and education to increase awareness and understanding of the existing fish consumption advisories and fishing restrictions; monitoring to evaluate and track contaminant concentrations in fish (primarily white croaker [WC] – a fish known to be impacted by DDTs) caught at or near the site

as well as those sold in retail fish markets and served in restaurants; and enforcement of existing commercial and recreational restrictions on WC fishing established by the California Department of Fish and Wildlife (CDFW); and (2) placement of an isolation cap (layer of clean sand) over the most contaminated and erosive area of sediment at PV Shelf. The IROD also promulgated cleanup objectives for the interim cap, and cleanup goals for sediment, for ocean water, and for WC.

Monitored Natural Recovery Program

The objectives of the MNR program included: (1) gathering data to establish the current condition of the sediment bed and compare findings to IROD cleanup levels; (2) supporting the possible remedial design (RD) of the interim isolation cap; (3) gathering data on current conditions of the water column and comparing findings to IROD cleanup levels; and (4) gathering data on current conditions of two COC-impacted fish species, barred sand bass (BSB) and WC, caught in the vicinity of PV Shelf, and comparing COC concentrations in fish tissue (skin-off filets) to IROD cleanup levels and to levels in fish caught far away from PV Shelf. The MNR sampling program included the elements described below.

- Sediment sampling program. Using sampling approaches and techniques similar to EPA's 2009 baseline sediment assessment, sediment cores were collected in October 2013 using a gravity coring device. Sixty-nine primary cores and 10 replicate cores were collected and processed to yield 1,025 samples and 150 replicate samples. Samples were tested for physical parameters including grain size and bulk density, and for chemical parameters including DDTs, PCBs, moisture content (MC), and organic carbon (OC).
- Water sampling using passive sampling devices (PSDs). PSDs including polyethylene devices (PEDs) and solid-phase microextraction devices (SPMEs) were prepared and then deployed at 17 locations along PV Shelf and at one reference location (at 3 or 4 depths per location). The devices were deployed in September 2013 and retrieved in October 2013, then tested for COCs at an analytical laboratory. A total of 207 PSD samples were tested.
- Water sampling for high resolution testing. Grab samples were collected at depth directly into sample bottles from locations along PV Shelf and from one reference location. The bottles were retrieved and sent to an analytical laboratory for testing of COCs using high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). The high resolution water study generated 137 primary samples and 11 replicates from 40 locations (at 3 or 4 depths per location).
- Fish collection for high resolution testing. Specimens of BSB and WC were caught from several collection areas extending from Ventura in the north to Huntington Flats in the south. The fishing period ran from June 2014 through August 2016; specimens were sent to an analytical laboratory for processing and testing. The catch yielded 301 samples of fish tissue

(skin-off filets; 143 BSB and 158 WC) that were tested for COCs using HRGC/HRMS, and for lipids.

Chemistry testing of all samples was done in conformance with EPA-approved quality assurance project plans (QAPPs). For each medium, COC chemistry results were organized into groupings as follows:

- Total DDTs – the summation of the o,p'- and p,p'- isomers of DDD, DDE, and DDT
- Total DDT Compounds – the summation of Total DDTs plus *p,p*'-DDMU and *p,p*'-DDNU
- Total PCBs (short list) – the summation of 29 individual PCB congeners (used for sediment goals in the IROD)
- Total PCBs (expanded list) – the summation of 46 individual PCB congeners
- OC normalization – for sediment, COC test results were also normalized for OC, in conformance with IROD cleanup goals.
- Bioactive layer – for sediment, COC test results for the 0-8-cm bed-depth interval were analyzed and processed (in addition to the results for the total EA bed), because that interval has been demonstrated to be the bioactive layer at PV Shelf.

For sediment, C Tech's Mining Visualization System was used to estimate average COC concentrations (both dry-weight values and OC normalized values) and total mass, both for the entire EA bed and for the 0-8-centimeter (cm) sediment bed-depth interval.

Results of the MNR Program

For each medium, maximum values were reported for samples collected near or just down-current (northwest) of the diffuser sections of the Sanitation Districts' ocean outfalls, along the 60-m isobath.

Maximum Values of Concentrations of COCs by Medium

Medium	*Total DDTs*	*Total DDT Compounds*	*Total PCBs (expanded list)*
Sediment in 0-8-cm bed-depth interval (milligrams per kilogram [mg/kg])	76 (1,400)	81 (1,500)	6.2 (140)
Sediment in total bed (mg/kg)	310 (6,840)	350 (7,320)	35 (450)
Water using passive sampling devices (PSDs) (nanograms per kilogram [ng/L])	11	13	0.31
Water using high resolution analyses (ng/L)	1.6	3.3	0.19
Fish (micrograms per kilogram [ug/kg])	2,400	3,200	260

Notes
1. The 0-8-cm bed-depth interval in the sediment bed is the bioactive zone at PV Shelf.
2. Units of concentrations match the units used for cleanup goals in the IROD.
3. For sediment, values in parentheses are OC normalized, and may be for different sediment samples.

Sediment results indicated that widespread deposits of DDT and PCB contamination still exist at PV Shelf. For the 0-8-cm bed-depth interval, a DDT hot spot (an area with dry-weight concentrations exceeding 20 milligrams per kilogram [mg/kg]) remains near the center of the diffuser array. A PCB hot spot (an area with dry-weight concentrations exceeding 1 mg/kg) is also present at the same location. Other observations based on the results of the MNR program are:

- In all three media (sediment, water, and fish), p,p'-DDE and p,p'-DDMU are the dominant isomers of DDT. In sediment, these two chemicals accounted for 50% and 30%, respectively, of the mass of Total DDT Compounds.
- Significant amounts of COCs remain in the sediment bed. Patterns of distribution of COCs in the sediment bed at PV Shelf do not appear to have changed appreciably over time. "Hot spot" areas persist near the outfall diffusers along the 60-m isobath. The outfall area (OA), defined as the general area within 1.5 km of the diffusers, contains roughly 47% of the total COC mass.
- For a significant number of primary-replicate pairs of sediment results for Total DDT Compounds and for Total PCBs (expanded list), the relative percent difference (RPD) values exceeded the project goal of 50%; this is likely an indication of the heterogeneity in the sediment bed.
- For water, the values of maximum COC concentrations at nearly every sample location were greatest at the deepest sample depth (i.e., closest to the sediment bed). Based on the results of high resolution grab water sampling, concentrations exceeded applicable IROD cleanup goals (both human health and ecological) at many locations, most notably at the diffusers and down-current (northwest) of the diffusers.
- For fish, the highest values for maximum COC concentrations and for average COC concentrations were reported in samples from specimens caught in the collection areas nearest the outfall diffusers. This trend was observed both for BSB and WC.
- For each fish collection area, the 95% upper confidence limit (UCL) was calculated for both fish species (BSB and WC). The resulting values are regarded as the exposure point concentrations (EPCs) for the collection area. For DDTs in WC, the EPC exceeded the IROD cleanup goal in the outfall diffusers collection area and in the two areas down-current of the diffusers. For PCBs in WC, the EPC exceeded the IROD cleanup goal in the collection area at the outfall diffusers and at the area immediately down-current. There are no IROD goals for BSB.

Time Trends

Results for each medium were compared to results from previous investigations at PV Shelf.

DDTs in Sediment. Results from EPA's previous sediment sampling event conducted in 2009 were compared to results from the 2013 event. For Total DDTs in the upper 8 cm of the sediment bed, the respective mean concentrations (average concentrations based on output from the geostatistical model) were 56 mg/kg OC and 77 mg/kg OC. The respective mass estimates of Total DDTs for the upper 8-cm interval were 1.7 metric tons (MT) and 3.6 MT. The respective estimates of mass of Total DDTs for the entire EA bed were 14 MT and 42 MT. The apparent increases in concentrations and total mass were attributed primarily to the heterogeneity of the sediment bed. However, the mass values for both events are significantly less than historical estimates from researchers in the 1990s.

- PCBs in Sediment. Results from EPA's previous event conducted in 2009 were compared to the 2013 event, using the short list of 29 congeners. For Total PCBs in the upper 8 cm of the sediment bed, the respective mean concentrations (average concentrations based on output from the geostatistical model) were 3 mg/kg OC and 5 mg/kg OC. The respective mass estimates of Total PCBs for the upper 8-cm interval were 0.11 MT and 0.28 MT. For the entire EA bed, the respective estimates were 1.0 MT and 2.9 MT. As with DDTs, the apparent increases in concentrations and total mass were attributed primarily to the heterogeneity of the sediment bed.
- DDTs in Water. Results from a 1997 (high volume) study conducted at PV Shelf by the Southern California Coastal Water Research Project (SCCWRP) indicated that Total DDTs were about 5 nanograms per liter (ng/L) for samples collected along the 40-m and 60-m isobaths, near the ocean bottom, and at locations near the outfall diffusers. This MNR high resolution event showed results ranging from about 0.01 to 1 ng/L for these locations/depths. The corresponding PSD results (2010 and 2013) were higher, ranging from about 3 to 7 ng/L. Rigorous data comparisons and time trend analysis were not possible, due to variabilities in sample collection methods, analytical methods, ocean currents (mixing), and, for PSD events, uncertainties regarding equilibrium dynamics and COC partitioning between the sampling device and the water column, and temperature effects.
- PCBs in Water. Results from the SCCWRP study indicated that Total PCBs were in the range of 0.4 ng/L for samples collected along the 40-m and 60-m isobaths, near the ocean bottom, at locations near the outfall diffusers. This MNR high resolution event showed results ranging from about 0.005 to 0.1 ng/L for these locations/depths. The corresponding PSD results (2010 and 2013) were higher, ranging from about 0.03 to 0.1 ng/L. Similar to DDTs, rigorous data comparisons and time trend analysis were not possible, due to variabilities in sample collection methods, analytical methods, ocean current (mixing), and, for PSD events, uncertainties regarding equilibrium dynamics, COC partitioning between the sampling device and the water column, and temperature effects.
- DDTs in Barred Sand Bass. A 2002/2004 study jointly conducted by the National Atmospheric and Oceanic Administration (NOAA) and EPA (collections from August 2002 to June 2003), indicated that the average concentration of total DDTs in BSB caught in the area closest to the outfalls, was 880 micrograms per kilogram (ug/kg), and 300 ug/kg for fish

caught off Bluff Cove/Palos Verdes Point (about 10 km northwest of the outfalls). BSB results published by the Sanitation Districts in 2014 (collected from June to October 2012) were 130 ug/kg and 65 ug/kg for these areas, respectively, and 70 ug/kg for BSB caught off Long Point/Point Vicente (about 5 km northwest of the outfalls). Results from this MNR event (June 2014 to August 2016 collections) showed values of Total DDTs in BSB to be 290 ug/kg, 97 ug/kg, and 140 ug/kg for these areas, respectively. Rigorous data comparisons and time trend analysis for DDTs in BSB were not possible, due to variabilities in sample collection methods, analytical methods, and uncertainties regarding fish age, mobility, and foraging habits.

PCBs in Barred Sand Bass. The 2002/2004 NOAA/EPA study indicated that the average concentration of PCB congeners in BSB caught in the area closest to the outfalls was 98 ug/kg, and 40 ug/kg for fish caught off Bluff Cove/Palos Verdes Point. Based on the most recent available Sanitation Districts BSB data for total Aroclors published in 2014, results were lower than for NOAA and above the data from this MNR report, at 67 ug/kg and 17 ug/kg, from these respective areas, and at 31 ug/kg for BSB caught off Long Point/Point Vicente, about 5 km northwest of the outfalls. Results from this MNR event showed values of 35 ug/kg, 16 ug/kg, and 23 ug/kg for these areas. Rigorous data comparisons and time trend analysis were not possible, due to variabilities in sample collection methods, analytical methods, congeners versus Aroclor lists, and uncertainties regarding fish age, mobility, and foraging habits.

- DDTs in White Croaker. The 2002/2004 NOAA/EPA study (collections from September 2002 to June 2004) indicated that the average concentration of DDTs for WC caught in the area nearest the outfall was 1,400 ug/kg; and for WC caught off Long Point/Point Vicente, about 5 km northwest of the outfalls, the value was 990 ug/kg. Results from this MNR event (October 2014 to July 2016 collections) showed values of Total DDTs to be 770 ug/kg for both of these areas. Results published by the Sanitation Districts in 2016 (collected in November and December 2015) were 2,900 ug/kg and 1,600 ug/kg, respectively. Rigorous data comparisons and time trend analysis were not possible, due to variabilities in sample collection methods, analytical methods, and uncertainties regarding fish age, mobility, and foraging habits. However, the Sanitation Districts has published fish results since the late 1990s, and the data set indicates a dramatic reduction in DDT concentrations in WC since that time.
- PCBs in White Croaker. The 2002/2004 NOAA/EPA study indicated that the average concentration of PCBs for WC caught in the area closest to the outfalls was 350 ug/kg; for fish caught in the area off Long Point/Point Vicente, the value was 120 ug/kg. Results from this MNR event showed values of 82 ug/kg and 120 ug/kg for these same areas. Results published by the Sanitation Districts in 2016 were 270 ug/kg and 150 ug/kg, respectively. Rigorous data comparisons and time trend analysis were not possible, due to variabilities in sample collection methods, analytical methods, congener lists, and uncertainties regarding fish age, mobility, and foraging habits. However, the Sanitation Districts has published fish results since the late 1990s, and data indicate a drop in PCB concentrations in WC.

Compliance with IROD

Results for each medium were compared to the cleanup criteria set forth in the IROD. As indicated in the table below, though cleanup objectives related to the isolation cap appear to have been met, IROD cleanup goals for sediment, water, and fish have not been met.

Overall, conditions at PV Shelf regarding COC contamination in sediment appear to be improving – concentrations in the 0-2-cm bed-depth interval continue to decline, and concentrations in the 0-8-cm bed-depth interval were lower than the performance objectives related to the interim cap described in the IROD, even without the cap. However, significant areas of sediment remain highly contaminated, and COC concentrations in samples of water and fish exceeded the associated IROD cleanup goals, both for DDTs and PCBs. EPA will continue the MNR sampling program to evaluate the effectiveness of MNR and to develop final remediation alternatives for PV Shelf cleanup.

Summary of IROD Compliance

Medium/COC	*Representative value*	*IROD post-capping objective*	*IROD interim cleanup level*
Sediment (average concentrations)			
Total DDTs (mg/kg OC)	77	78	46
Total PCBs - short list (mg/kg OC)	5	7	7
Total PCBs (mg/kg OC)	10	-	-
Water (human health)			
p,p'-DDE (ng/L)	1.1	-	0.22
Total PCBs (ng/L)	0.19	-	0.064
Water (ecological)			
Total DDTs (ng/L)	1.6	-	1
Total PCBs (ng/L)	0.19	-	30
White Croaker - Outfall Collection Area			
Total DDTs (ug/kg)	1,000	-	400
Total PCBs (ug/kg)	98	-	70

Abbreviations

mg/kg OC - milligrams per kilogram normalized for organic carbon
ug/kg - micrograms per kilogram (parts per billion)
ng/L - nanograms per liter (parts per trillion)

Notes

1. For Total PCBs, all values are for the expanded congener list, unless otherwise noted.
2. For sediment, all values are for the 0-8-cm bed-depth interval (the bioactive zone at PV Shelf). The representative values are the mean (average) OC normalized concentrations as generated by the current output of the geostatistical model.
3. For water, the representative values are maximum concentrations from the current MNR data set. The representative values for p,p'-DDE and for Total DDTs are from the near-bottom sample for location 4C, and the representative value of Total PCBs is from the mid-column sample at location 7C.
4. For fish, the representative value is the exposure point concentration.

Lessons Learned

Difficulties were encountered in duplicating sampling program design and in analyzing time trends, due to inconsistent approaches in past sample collections, laboratory analyses, and data processing. In future MNR monitoring events, approaches to sample collection, laboratory analysis, and data processing should be identical or similar to those used for this MNR study, and the sampling/collection locations used for this study should be reoccupied to the extent practical. This approach will be important for a meaningful comparison of data ("apples to apples") for examining time trends, assessing accurately the effectiveness of MNR, and determining whether COC concentrations have reached applicable cleanup levels.

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