Atmospheric Deposition Loads of Metals in Los Angeles Area

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This purpose of this memorandum is to (1) summarize the findings of previous studies on the air deposition loads of metals resulting from major air-emitter facilities in the Los Angeles Area and (2) use the existing information from the previous studies to estimate the direct and indirect atmospheric deposition loads of metals in the Los Angeles area in order to develop TMDL load reduction strategies for atmospheric deposition of metals.

Emissions of metals to the atmosphere and subsequent deposition, either directly to the waterbody surface or indirectly to the watershed, which is then washed-off during rain events, may contribute to the contamination observed in the surface waters throughout the urban Los Angeles region. In this memorandum, the estimates of atmospheric loads from direct and indirect sources will be discussed separately. The total loads of metals resulting from atmospheric deposition to a watershed can be computed as the sum of the direct and indirect loading.

In order to investigate sources of air deposition, on May 15, 2007, the Regional Board Executive Officer issued California Water Code Section 13267 orders to the 29 largest air emitters of metals in the Region. The 13267 Orders required reports on the fate and transport of metals emitted by the 29 facilities. Twenty-one facilities completed the required reports (four facilities were exempt from the requirements and four facilities received follow-up orders/letters). This memo summarizes the results of those studies and provides estimates of air deposition based on the results.

1.0 Estimates of Direct Atmospheric Deposition Loads of Metals

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Direct atmospheric deposition is the amount of metals deposited directly onto the surface of a waterbody. Direct atmospheric deposition from the 21 facilities who responded to the 13267 orders was quantified by multiplying the surface area of the waterbody times the rate of atmospheric deposition estimated by the facilities. As such, the direct loads of metals to waterbodies were calculated using the facilities' modeled deposition fluxes. Of the firms that submitted report materials in response to the 13267 Order, two firms did not complete modeling, five firms used the Industrial Source Complex Short Term (ISCST3) model, six firms used the AERMOD model, and the refinery group, representing seven WSPA member refineries, utilized the CALPUFF model to estimate the deposition fluxes. All of the models that were used are USEPA approved/recommended models for estimating dispersion of pollutants emitted by a source and predicting concentrations at downwind receptor locations. ISCST3 and AERMOD are steady-state plume dispersion models and CALPUFF is a non-steady-state puff

dispersion model. To estimate direct deposition, most of the firms plotted the model-predicted deposition fluxes across the landscape. The WSPA member refinery facilities interpolated modeled deposition fluxes to the surface of each nearby waterbody using ArcView. For each of the models, the atmospheric deposition flux to each computational grid cell was multiplied by the area of the grid cell and the result was summed over the entire surface area of each waterbody to estimate the loads of copper, lead, mercury and zinc to these waterbodies. The estimated results are shown in Table 1. In general, these numbers of direct atmospheric deposition are small because the actual surface area of the waterbody is small.

2.0 Estimates of Indirect Atmospheric Deposition Loads of Metals

Indirect atmospheric deposition is the amount of airborne metals deposited on land surface that may be washed into a water body during storm events. The amount of deposited metals available for transport to Los Angeles area waterbodies (i.e., not infiltrated) is unknown. However, as indicated in previous studies, deposition of metals to the surface area of the watershed may be substantial -- on the order of several thousand kilograms per year (Sabin et al., 2004). In a subsequent study, Sabin et. al. found that for a small impervious catchment, atmospheric deposition could potentially account for 57-100% of the metals in storm runoff generated in the study area (Sabin et. al., 2005). That study assumed that all the metals deposited on the catchment were available for removal. However, in large, varied watersheds, such as the Los Angeles River and San Gabriel River watersheds, not all metals deposited on the land surface may be available for removal by runoff. Furthermore, indirect loading varies depending on the amount of rainfall and size of storms in a given year.

The reports in response to the 13267 Order from different companies used different approaches and considerations to calculate the indirect deposition emanating from their facilities. There was more variability in the indirect calculations. About a third of the respondents provided very simplified reports and did not separate atmospheric deposition into direct and indirect components. Two firms made the assumption that all deposition to land could become indirect deposition. More than half of the respondents applied a watershed transmission efficiency (WTE) factor to adjust the amount of land deposition that would actually reach area waterways and become indirect deposition. Five groups used WTEs developed by Sabin et al, 2004 and Sabin et al, 2005. Several other groups used alternative WTEs. The indirect atmospheric deposition provided by theses dischargers is presented in Table 2. As can be seen from this table, the indirect atmospheric deposition from the air emitter facilities is small compared to previous studies conducted by Sabin et al. (2004). The indirect deposition presented in Table 2 does not include deposition from other air sources and may not account for the wash-off effect on the land surface during storm events. Therefore, to estimate the atmospheric deposition from all indirect sources, the metals loading from each watershed during storm events needs to be analyzed first. Metals loading from each watershed was calculated by multiplying the volume of runoff with the event mean concentration (EMC) for the watershed based on each land use in the watershed. The detailed procedure of calculation is described as follows.

Precipitation data from each watershed was assumed to be constant in the analysis to estimate storm runoff. The annual runoff from each watershed was estimated by multiplying the average annual rainfall by the area of the watershed occupied by each land use and an appropriate runoff coefficient for each land use (Table 3). Table 4 provides the results of estimated annual runoff volume from each land use in the watersheds surrounding the air emission facilities.

Metals loading in stormwater runoff vary with land use. Thus, to estimate the metals loading in stormwater runoff from each land use in the watershed, the annual runoff volume from each land use (Table 4) was multiplied by the corresponding annual event mean concentration of metals for each land use type (Table 5) and a wash-off factor that accounts for the fraction of sediment being washed off from each land use during a storm event (Table 6). The event mean concentrations of metals for each land use (Table 5) are based on previous studies performed by Southern California Coastal Water Research Project (SCCWRP) (2007). Table 7 shows the estimated results of the metals loading from the surrounding watersheds in stormwater runoff.

Then, the atmospheric deposition from all indirect sources can be estimated by dividing the estimated metals loading from stormwater runoff (Table 7) by the WTE estimated by Sabin et al. (2004). Sabin et al. (2004) calculated the ratio of wet-weather water runoff to indirect atmospheric deposition (referred to as the watershed transmission efficiency in that report) for the Los Angeles river watershed, Ballona Creek watershed, and Dominguez Channel watershed (Table 8). In this Table, the transmission efficiencies for Santa Monica Bay are assumed to be the same as those for Ballona Creek, and similarly, the transmission efficiencies for San Gabriel River watershed are assumed to be the same as those for Los Angeles River watershed. The estimates of indirect loading of metals from all sources of atmospheric deposition are presented in Table 9.

3.0 Summary

According to the information provided by the dischargers in response to California Water Code Section 13267 Orders, the estimated direct atmospheric deposition from the largest air emitters of metals in the Los Angeles region (Table 1) is considered an appropriate estimate using technically sound models so far. However, the indirect atmospheric deposition provided by the dischargers presented in Table 2 is relatively small compared to the results of previous studies.

The estimate of indirect atmospheric deposition from all indirect sources shown in Table 9 is based on the transmission efficiency, which is the relationship between indirect atmospheric deposition of metals and stormwater runoff and requires further study. However, without new field data to update the transmission efficiency, the estimate presented in Table 9 for different rainfall is considered by staff to be reasonable for the purposes of this analysis. Average annual precipitation for the Los Angeles area is highly variable and terrain-dependent, ranging from twelve inches at the ocean to about twice that in the foothills. According to the historical rainfall data at Los Angeles Airport, the average annual rainfall is about 12 inches. Thus, if the average annual rainfall of 12 inches is assumed for the whole watershed for all watersheds in the Los Angeles area, the indirect atmospheric deposition for different watersheds are presented in Table 10.

The total loads of metals resulting from atmospheric deposition to a watershed can be computed as the sum of the direct and indirect loading and the predicted results are shown in Table 11. The comparison of predicted atmospheric deposition loads of metals with measured data obtained from previous studies is presented in Table 12. As can be seen from Table 12, the present prediction of deposition loads for copper and lead are fairly good. However, as compared with measured data, the predicted results of deposition loads for zinc are underestimated. In general, the present estimates of atmospheric deposition of metals fully rely on the EMC of each land use and the watershed transmission efficiency ratio. Clearly, the more accurate EMC and WTE that we have, the better predicted results for atmospheric deposition loads of metals we can get.

4.0 References

1. "Model Development for Simulation of Wet-Weather Metals Loading from the Los Angeles River Watershed", prepared for USEPA Region 9 and Los Angeles Regional Water Quality Control Board, prepared by Tetra Tech Inc, May 2004.
2. "Model Development for Simulation of Wet-Weather Metals Loading from the San Gabriel River Watershed", prepared for USEPA Region 9 and Los Angeles Regional Water Quality Control Board, prepared by Tetra Tech Inc, October 2005.
3. "Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors", prepared for USEPA Region 9 and Los Angeles Regional Water Quality Control Board, prepared by Tetra Tech, Inc, July 2006.
4. "Santa Monica Bay Beach Wet Weather Bacteria TMDL", Los Angeles Regional Water Quality Control Board, Preliminary Draft, June 2002.
5. "Modeling Stormwater Mass Emissions to the Southern California Bight", Drew Ackerman and Ken Schiff, Journal of the American Society of Civil Engineers 129, 2003.
6. "Atmospheric Dry Deposition of Trace Metals in the Los Angeles Coastal Region", Lisa D. Sabin, Kenneth C. Schiff, Jeong Hee Lim, and Keith D. Stolzenbach, 2003-2004 Annual Report, Southern California Coastal Water Research Project (SCCWRP), Page 50-60, 2004.
7. "Metal Dry Deposition Rates Along A Coastal Transect In Southern California", Technical Report 509, Southern California Coastal Water Research Project (SCCWRP), March 2007.
8. "Contribution of Trace Metals from Atmospheric Deposition to Stormwater Runoff in a Small Impervious Urban Catchment", Lisa D. Sabin, Jeong Hee Lim, Keith D. Stolzenbach, Kenneth C. Schiff, Water Research 30, Page 3929-3937, 2005.
9. "Modeling Stormwater Mass Emissions to the Southern California Bight", Drew Ackerman and Kenneth C. Sciff, Journal of the American Society of Civil Engineers 129, 2003.
10. "Modeling and Analysis of Metals Emissions from WSPA Member Facilities, Los Angeles Region, California", prepared for Western States Petroleum Association, prepared by Flow Science Inc. and ERM, October 9, 2008.
11. "Dry Deposition and Resuspension of Particle-Associated Metals Near a Freeway in Los Angeles", Lisa D. Sabin, Jeong Hee Lim, Maria Teresa Venezia, Arthur M. Winer, Kenneth C. Schiff and Keith D. Stolzenbach, Atmospheric Environment 40, 2006.
12. "Dominguez Watershed Management Master Plan" prepared for County of Los Angeles Department of Public Works, prepared by MEC and Brown & Caldwell, April 2004.
13. "Sources, Patterns and Mechanism of Storm Water Pollutant Loading from Watersheds and Land Uses of the Greater Los Angeles Area, California,

USA”, Technical Report 510, Southern California Coastal Water Research Project, March 2007.
14. “Concentration, Size Distribution, and Dry Deposition Rate of Particle Associated Metals in the Los Angeles Region”, J.H. Lim, L.D. Sabin, K.C. Schiff and K.D. Stolzenbach, Atmospheric Environment 40, 2006.

Table 1 Direct Atmospheric Deposition of Metals Provided by Dischargers

Metal / Direct Source	Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed	Santa Monica Bay Watershed	Ballona Creek Watershed
Copper (g/year)					
WSPA			43	1402	
Rangers Die Casting	21909				
Total	21909		43	1402	
Lead (g/year)					
WSPA			32	641	
Exide Tech	11340				
Trojan Battery (two facilities)		83			
Total	11340	83	32	641	
Mercury (g/year)					
WSPA			13	507	
Total			13	507	
Zinc (g/year)					
WSPA			490	13183	
Bandag Licensing	454				
Quemetco		222			
US Borax			3112		
Western Tube and Conduit	907		454		
Total	1361	222	4056	13183	

Sources:
1. The reports in response to the 13267 Orders from different companies used different approaches, models and considerations to calculate the deposition emanating from their facilities. Of the firms that submitted report materials, two firms did not complete modeling, five firms used the ISCST3 model, and six firms used AERMOD model. The refinery group utilized CALPUFF model.

Table 2 Indirect Atmospheric Deposition of Metals Provided by Dischargers

Metal / **Indirect Source**	**Los Angeles River Watershed**	**San Gabriel River Watershed**	**Dominguez Channel and LA/LB Harbors Watershed**	**Santa Monica Bay Watershed**	**Ballona Creek Watershed**
Copper (g/year)					
WSPA	490 - 2600	270 - 1100	570 - 1900	500 - 2100	170 – 800
Los Angeles Die Casting	17690				
Lansco Die Casting		113854			
Shultz Steel Co	46				
Total	18226 - 20336	114124 - 114954	570 - 1900	500 - 2100	170 – 800
Lead (g/year)					
WSPA	130 - 1300	87 – 620	140 - 930	130 - 930	50 - 370
Exide Tech	498469				
Trojan Battery	40	2935			
Quemetco Inc		13912			
Total	498639 - 498809	16934 - 17467	140 - 930	130 - 930	50 - 370
Mercury (g/year)					
WSPA	100 - 1000	43 - 430	72 - 720	77 - 770	30 – 290
Total	100 - 1000	43 - 430	72 - 720	77 - 770	30 - 290
Zinc (g/year)					
WSPA	5500 - 25000	3400 - 11000	7500 - 18000	6100 - 20000	2200 - 7600
Bandag Licensing	13154	8165			
US Borax	2431	2032	25751	857	
Western Tube and Conduit	3175		41731		
Total	24260 - 43760	13597 - 21197	74982 - 85482	6957 - 20857	2200 - 7600

Sources:

1. The reports in response to the 13267 Orders from different companies used different approaches and considerations to calculate the indirect deposition emanating from their facilities. There was more variability in the indirect calculations. About a third of the respondents provided very simplified reports and did not separate atmospheric deposition into direct and indirect components. Two firms made the assumption that all deposition to land could become indirect deposition. More then half of the respondents applied a watershed transmission efficiency (WTE) factor to adjust the amount of land deposition that would actually reach area waterways and become indirect deposition. Five groups used WTEs developed by Sabin et al, 2004 and Sabin et al, 2005. Several other groups used alternative WTEs.

Table 3 Watershed Area in Each Land Use and Runoff Coefficient Used in the Analyses

	Residential	Commercial	Industrial	Open	Other	Total
Los Angeles River Watershed						
Area ($mile^2$)	305	64	87	368	10	834
Runoff Coefficient	0.5	0.7	0.6	0.2	0.1	
San Gabriel River Watershed						
Area ($mile^2$)	169	78	27	381	45	700
Runoff Coefficient	0.5	0.7	0.6	0.2	0.1	
Dominguez Channel and LA/LB Harbors Watershed						
Area ($mile^2$)	50	14	34	26	11	133
Runoff Coefficient	0.5	0.7	0.6	0.2	0.1	
Santa Monica Bay Watershed						
Area ($mile^2$)	121	22	11	226	29	408
Runoff Coefficient	0.5	0.7	0.6	0.2	0.1	
Ballona Creek Watershed						
Area ($mile^2$)	70	16	7	20	13	125
Runoff Coefficient	0.5	0.7	0.6	0.2	0.1	

Sources:

1 "Model Development for Simulation of Wet-Weather Metals Loading from the Los Angeles River Watershed", prepared for USEPA Region 9 and Los Angeles Regional Water Quality Control Board, prepared by Tetra Tech, Inc, May 2004.

2. "Model Development for Simulation of Wet-Weather Metals Loading from the San Gabriel River Watershed", prepared for USEPA Region 9 and Los Angeles Regional Water Quality Control Board, prepared by Tetra Tech, Inc, October 2005.

3. "Watershed Model Development for Simulation of Loadings to the Los Angeles/Long Beach Harbors", prepared for USEPA Region 9 and Los Angeles Regional Water Quality Control Board, prepared by Tetra Tech, Inc, July 2006.

4. "Dominguez Watershed Management Master Plan" prepared for County of Los Angeles Department of Public Works, prepared by MEC and Brown & Caldwell, April 2004.

5. "Santa Monica Bay Beach Wet Weather Bacteria TMDL", Los Angeles Regional Water Quality Control Board, Preliminary Draft, June 2002.

6. "Modeling Stormwater Mass Emissions to the Southern California Bight", Drew Ackerman and Ken Schiff, Journal of the American Society of Civil Engineers 129, 2003.

Table 4 Estimates of Runoff Volume in Each Land Use (unit:hm^3/year)

	Residential	Commercial	Industrial	Open	Other	Total
For Annual Rainfall= 10 inch						
Los Angeles River Watershed	100.4	29.5	34.4	48.4	0.7	213.3
San Gabriel River Watershed	55.7	36.1	10.7	50.1	2.9	155.6
Dominguez Channel and LA/LB Harbor Watershed	16.3	6.3	13.2	3.4	0.7	39.9
Santa Monica Bay Watershed	39.7	10.0	4.2	29.7	1.9	85.5
Ballona Creek Watershed	22.9	7.5	2.7	2.6	0.8	36.6
For Annual Rainfall = 12 inch						
Los Angeles River Watershed	120.4	35.4	41.2	58.1	0.8	256.0
San Gabriel River Watershed	66.8	43.3	12.9	60.2	3.5	186.7
Dominguez Channel and LA/LB Harbor Watershed	19.6	7.6	15.9	4.1	0.8	47.9
Santa Monica Bay Watershed	47.6	12.0	5.0	35.6	2.3	102.6
Ballona Creek Watershed	27.5	9.0	3.3	3.1	1.0	43.9
For Annual Rainfall = 14 inch						
Los Angeles River Watershed	140.5	41.3	48.1	67.8	0.9	298.6
San Gabriel River Watershed	77.9	50.5	15.0	70.2	4.1	217.8
Dominguez Channel and LA/LB Harbor Watershed	22.9	8.8	18.5	4.7	1.0	55.9
Santa Monica Bay Watershed	55.6	14.0	5.9	41.6	2.7	119.7
Ballona Creek Watershed	32.1	10.5	3.8	3.6	1.2	51.2

Table 5 Event Mean Concentration of Metals in Each Land Use

Metal	Residential	Commercial	Industrial	Open	Other
Total Copper (µg/L)	18	17	33	8	20
Total Lead (µg/L)	8	4	19	1	9
Total Zinc (µg/L)	103	156	550	23	151
Total Mercury (µg/L)	0.04	0.02	0.06	0.07	0.11

Sources:

1. "Sources, Patterns and Mechanism of Storm Water Pollutant Loading from Watersheds and Land Uses of the Greater Los Angeles Area, California, USA", Technical Report 510, Southern California Coastal Water Research Project, March 2007.
2. "Modeling Stormwater Mass Emissions to the Southern California Bight", Drew Ackerman and Kenneth C. Sciff, Journal of the American Society of Civil Engineers 129, 2003.

Table 6 Wash-off Factor of Metals in Each Land Use

Metal	Residential	Commercial	Industrial	Open	Other
For Copper	0.8	1	0.3	0.12	0.3
For Lead	0.8	1	0.15	0.02	0.1
For Zinc	7.5	10.2	4	0.5	2.5
For Mercury	0.8	1	0.3	0.12	0.3

Source:

1. "Model Development for Simulation of Wet-Weather Metals Loading from the San Gabriel River Watershed", Appendix B - Water Quality Parameters for the San Gabriel River Wet Weather Models prepared for USEPA Region 9 and Los Angeles Regional Water Quality Control Board, prepared by Tetra Tech, Inc, October 2005.

Table 7 Mass Loadings of Metals in Storm Water Runoff

Metal	Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed	Santa Monica Bay Watershed	Ballona Creek Watershed
For Annual Rainfall =10 inch					
Copper (Kg/year)	2337	1587	481	823	492
Lead (Kg/year)	860	535	168	308	185
Zinc (Kg/year)	8796	5270	2333	2745	968
Mercury (Kg/year)	4.8	3.2	0.9	1.9	1.0
For Annual Rainfall =12 inch					
Copper (Kg/year)	2804	1905	577	987	590
Lead (Kg/year)	1032	642	202	370	222
Zinc (Kg/year)	10555	6324	2800	3294	1162
Mercury (Kg/year)	5.8	3.9	1.1	2.2	1.2
For Annual Rainfall =14 inch					
Copper (Kg/year)	3272	2222	673	1152	689
Lead (Kg/year)	1204	749	235	432	259
Zinc (Kg/year)	12314	7378	3267	3843	1356
Mercury (Kg/year)	6.8	4.5	1.3	2.6	1.4

Table 8 Transmission Efficiency (Ratio of Stormwater Runoff to Indirect Atmospheric Deposition) Estimated by Sabin et al. 2004

Metal	Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed	Santa Monica Bay Watershed	Ballona Creek Watershed
Copper	0.19	0.19	0.31	0.21	0.21
Lead	0.09	0.09	0.14	0.11	0.11
Zinc	0.22	0.22	0.43	0.29	0.29
Mercury	0.10	0.10	0.10	0.10	0.10

Note: Transmission efficiencies for mercury were not available and 0.1 is selected for all watersheds.

Table 9 Indirect Atmospheric Deposition of Metals from All Sources for Different Rainfalls

Metal	Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed	Santa Monica Bay Watershed	Ballona Creek Watershed
For Annual Rainfall =10 inch					
Copper (Kg/year)	12300	8353	1551	3918	2343
Lead (Kg/year)	9553	5943	1201	2802	1684
Zinc (Kg/year)	39980	23953	5426	9465	3339
Mercury (Kg/year)	48.5	32.1	9.4	18.6	9.8
For Annual Rainfall =12 inch					
Copper (Kg/year)	14760	10024	1861	4702	2811
Lead (Kg/year)	11463	7132	1441	3362	2020
Zinc (Kg/year)	47976	28744	6511	11358	4006
Mercury (Kg/year)	58.2	38.6	11.3	22.3	11.8
For Annual Rainfall =14 inch					
Copper (Kg/year)	17220	11695	2171	5486	3280
Lead (Kg/year)	13374	8321	1681	3923	2357
Zinc (Kg/year)	55972	33534	7597	13250	4674
Mercury (Kg/year)	67.9	45.0	13.1	26.0	13.7

Table 10 Indirect Atmospheric Deposition of Metals from All Sources in Los Angeles Area for One Rainfall

	Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed	Santa Monica Bay Watershed	Ballona Creek Watershed
Copper (Kg/year)	14760	10024	1861	4702	2811
Lead (Kg/year)	11463	7132	1441	3362	2020
Zinc (Kg/year)	47976	28744	6511	11358	4006
Mercury (Kg/year)	58.2	38.6	11.3	22.3	11.8

Note: The values in this Table are based on annual rainfall of 12 inch.

Table 11 Total Atmospheric Deposition Loads of Metals in Los Angeles Area

	Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed	Santa Monica Bay Watershed	Ballona Creek Watershed
Copper (Kg/year)	14782	10024	1861	4703	2811
Lead (Kg/year)	11474	7132	1441	3363	2020
Zinc (Kg/year)	47977	28744	6515	11371	4006
Mercury (Kg/year)	58.2	38.6	11.31	22.8	11.8

Note: The values in this Table are based on annual rainfall of 12 inch.

Table 12 Comparison of Predicted Atmospheric Deposition of Metals with Measured Data in Los Angeles Area

		Los Angeles River Watershed	San Gabriel River Watershed	Dominguez Channel and LA/LB Harbors Watershed	Santa Monica Bay Watershed	Ballona Creek Watershed
Copper (Kg/year)	A	14782	10024	1861	4703	2811
	B	16551	NA	1508	NA	2130
	C	16000	NA	2100	NA	3500
Lead (Kg/year)	A	11474	7132	1441	3363	2020
	B	11822	NA	1383	NA	2366
	C	12000	NA	1600	NA	2000
Zinc (Kg/year)	A	47977	28744	6515	11371	4006
	B	102457	NA	9301	NA	9110
	C	80000	NA	9400	NA	13000
Mercury (Kg/year)	A	58.2	38.6	11.31	22.8	11.8
	B	NA	NA	NA	NA	NA
	C	NA	NA	NA	NA	NA

Note: A: Present Study Estimate; B: Measured by Lim et al. 2006 ; C: Measured by Sabin et al. 2004

Sources:

1. "Concentration, Size Distribution, and Dry Deposition Rate of Particle Associated Metals in the Los Angeles Region", J.H. Lim, L.D. Sabin, K.C. Schiff and K.D. Stolzenbach, Atmospheric Environment 40, 2006.
2. "Atmospheric Dry Deposition of Trace Metals in the Los Angeles Coastal Region", Lisa D. Sabin, Kenneth C. Schiff, Jeong Hee Lim, and Keith D. Stolzenbach, 2003-2004 Annual Report, Southern California Coastal Water Research Project (SCCWRP), Page 50-60, 2004.