Deposition of car shredder aerosols into water surfaces: The results of the DTSC Terminal Island study, 2008-2009

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The SA Recycling automobile and white metal shredder on Terminal Island, Port of Los Angeles, CA, was studied in summer, 2008, and Spring, 2009. The 2008 study was done before installation of new pollution control equipment, and the Spring 2009 study after this equipment was in operation.

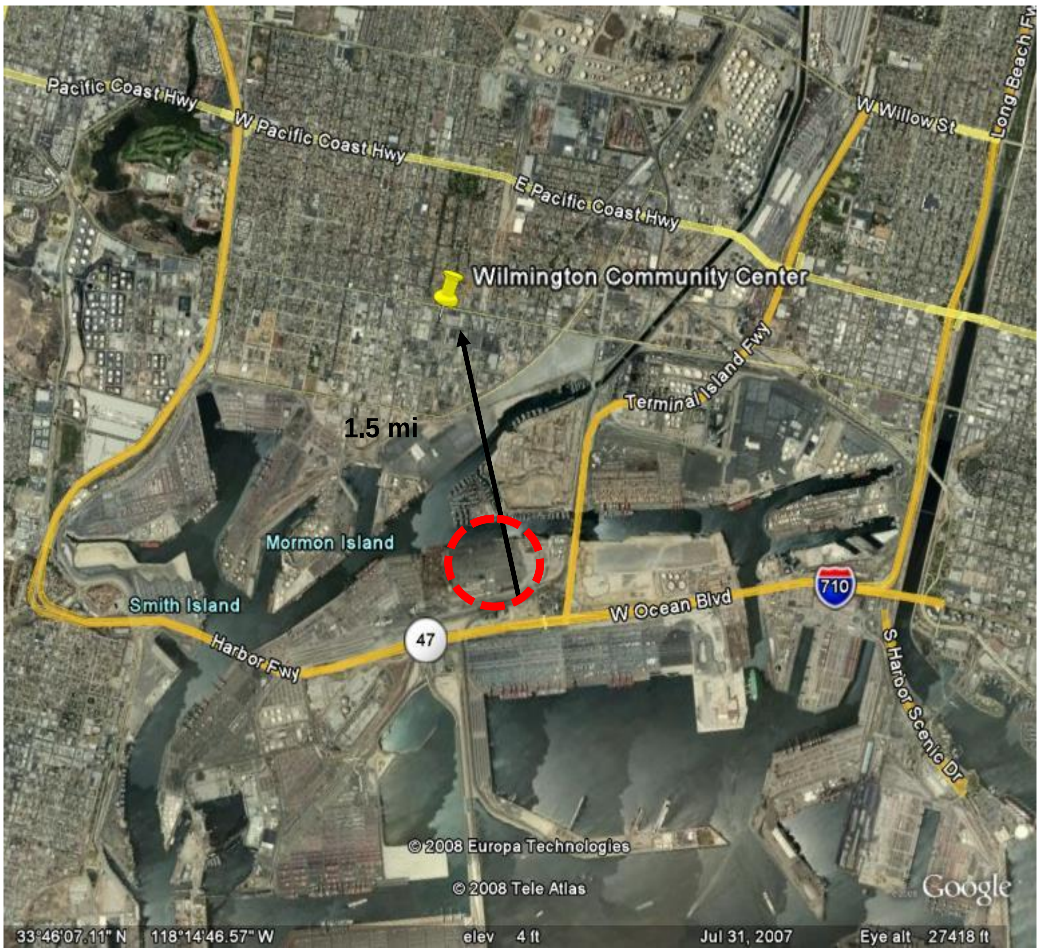


Figure 1 The Terminal Island study area. The SA Recycling plant is located within the dotted circle, and the Fire Station 49 sampling site directly across the water in the NNW direction.

Data on mass and elements are available in 8 size modes every three hours for 5 weeks in both studies at Fire Station 49, directly across the water from the shredder. During most hours, winds blew from the shredder to the sampling site from off the ocean.

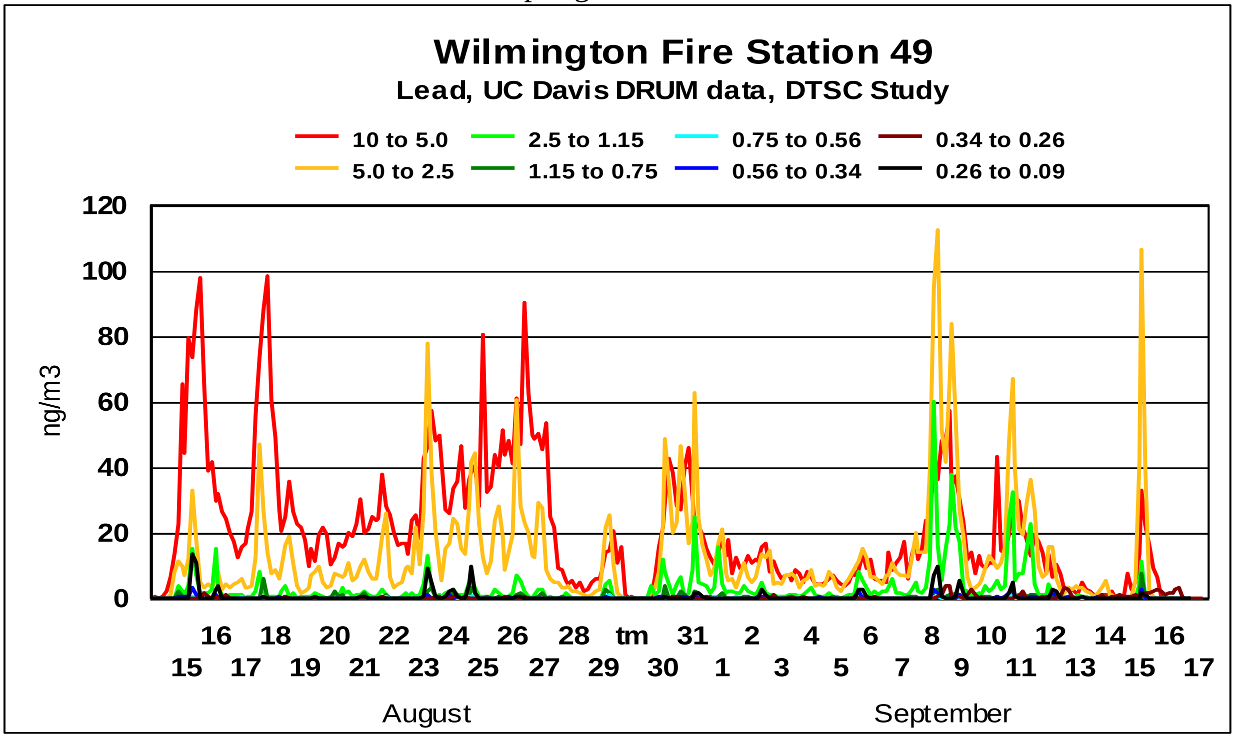


Figure 2 DRUM elemental data – lead, summer, 2008

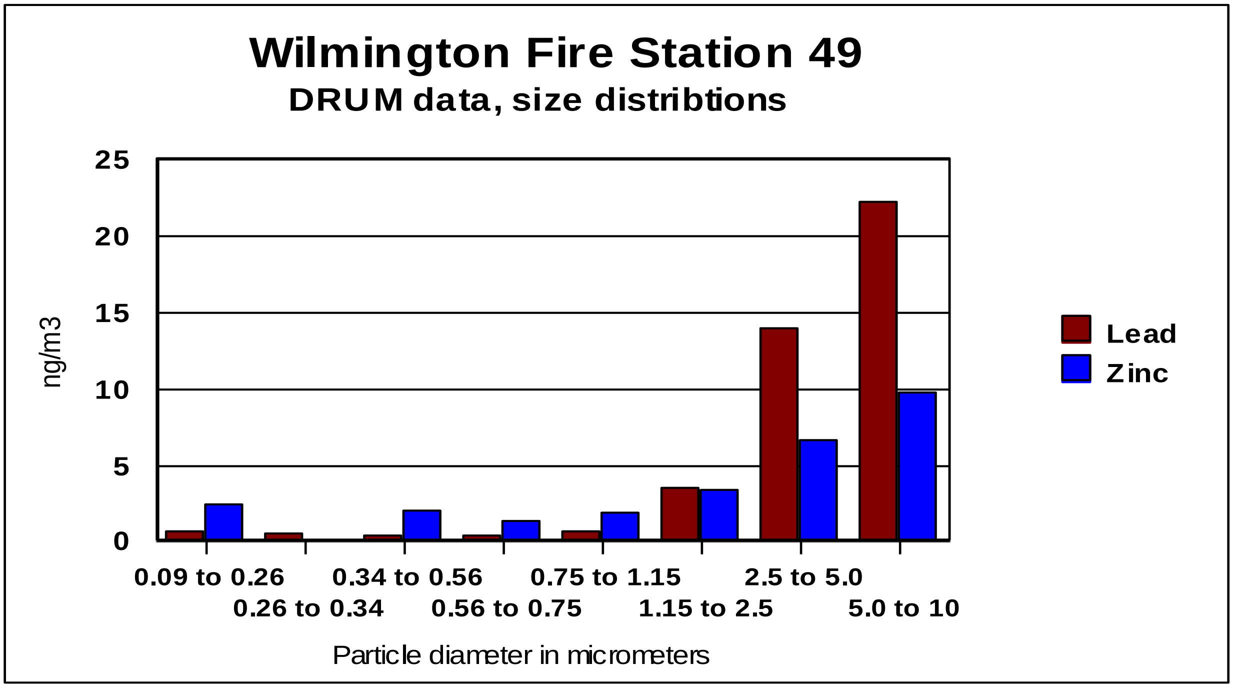


Figure 3 DRUM elemental data – size of lead and zinc, summer, 2008

In Table 1 (below) we present the average concentrations of air borne particles, summer, 2008, almost all of which occurred on winds that came from the Terminal Island; soil, (Al, Si, K, Ca, Ti, Mn, Sr, and about ½ of Fe) derived from SA operations, elemental pollutants (Cr, Cu, ½ of Fe, Zn, and Pb) from SA operations, toxic metals (V, Ni), most of which came from ocean going ships burning bunker oil, sulfur (from ships and diesel engines), and sea salt (Cl, Br). The particles > 1.15 µm have high settling velocities and will impact on water surfaces.

Soil elements	Al ng/m^3	Si ng/m^3	K ng/m^3	Ca ng/m^3	Ti ng/m^3	Mn ng/m^3	Fe ng/m^3	Sr ng/m^3
0.09 to 0.26	15.9	10.0	1.6	1.4	-0.35	0.18	8.6	0.11
0.26 to 0.34	18.2	13.5	2.8	1.4	-7.80	0.16	4.3	-0.01
0.34 to 0.56	47.6	30.6	4.4	3.5	0.14	0.39	5.3	0.15
0.56 to 0.75	31.0	24.9	3.8	6.0	0.72	0.29	4.9	0.09
0.75 to 1.15	32.3	40.5	9.2	18.4	1.44	0.34	12.5	0.12
1.15 to 2.5	61.0	104.3	28.2	61.2	4.71	0.77	37.0	0.35
2.5 to 5.0	166.0	301.1	51.1	128.3	11.67	1.81	83.5	0.43
5.0 to 10	244.4	427.1	54.9	167.9	13.79	2.43	99.1	0.36
Sum > 1.16	471.4	832.5	134.2	357.4	30.17	5.01	219.6	1.14

Pollutants	V ng/m^3	Cr ng/m^3	Mn ng/m^3	Fe ng/m^3	Ni ng/m^3	Cu ng/m^3	Zn ng/m^3	Pb ng/m^3
0.09 to 0.26	5.40	0.01	0.18	8.6	1.47	0.30	2.33	0.67
0.26 to 0.34	1.63	0.00	0.16	4.3	0.94	0.04	0.08	0.41
0.34 to 0.56	2.85	0.00	0.39	5.3	0.89	0.18	2.03	0.40
0.56 to 0.75	0.98	0.00	0.29	4.9	0.29	0.19	1.28	0.32
0.75 to 1.15	0.91	0.02	0.34	12.5	0.27	0.41	1.79	0.55
1.15 to 2.5	1.64	0.04	0.77	37.0	0.39	1.59	3.31	3.45
2.5 to 5.0	1.84	0.10	1.81	83.5	0.26	2.57	6.56	13.92
5.0 to 10	1.24	0.18	2.43	99.1	0.17	2.01	9.69	22.23
Sum > 1.16	4.71	0.32	5.01	219.6	0.82	6.17	19.57	39.60

Other	P ng/m^3	S ng/m^3	Cl ng/m^3	Br ng/m^3
0.09 to 0.26	11.25	290.2	0.0	0.28
0.26 to 0.34	16.27	409.9	0.0	0.01
0.34 to 0.56	31.27	821.9	0.0	0.22
0.56 to 0.75	18.12	476.8	0.0	0.28
0.75 to 1.15	11.33	311.8	3.0	0.17
1.15 to 2.5	7.36	209.1	75.3	0.57
2.5 to 5.0	7.38	196.0	255.9	0.79
5.0 to 10	7.03	140.6	283.1	0.92
Sum > 1.16	21.78	545.7	614.2	2.28

Table 1 Average aerosols elements seen at Fire Station 49, Wilmington, across the water from the Sa Recycling facility of Terminal Island, Port of Los Angeles.

The particles with sizes above 1 µm diameter settle efficiently into the water.

After the installation of enhanced air pollution control equipment, in Spring, 2009, very fine elements were sharply reduced, to 9% of prior values, and lead reduced to 40% of prior values.

Coarse particles, however, were roughly the same or even slightly higher than in 2008. This is interpreted as a successful reduction of prompt shredder very fine emissions, but continuing problems with mechanical mode particles mixed with soil, disturbed land surfaces, exposed piles, shredder operations, etc. This leads to predictions of deposition into the waterways directly downwind of the facility and the site where ships were loaded

Appendix A

Deposition of coarse toxic particles in Wilmington, CA for the Department of Toxic Substances Control (DTSC): Summer, 2008, and Spring, 2009; January 26, 2011, The UC Davis DELTA Group, Davis, CA 95616, Principal Investigators Tom Cahill, David Barnes, Project Manager, UC Davis DELTA Group, and Kristen Boberg, DTSC

Abstract:

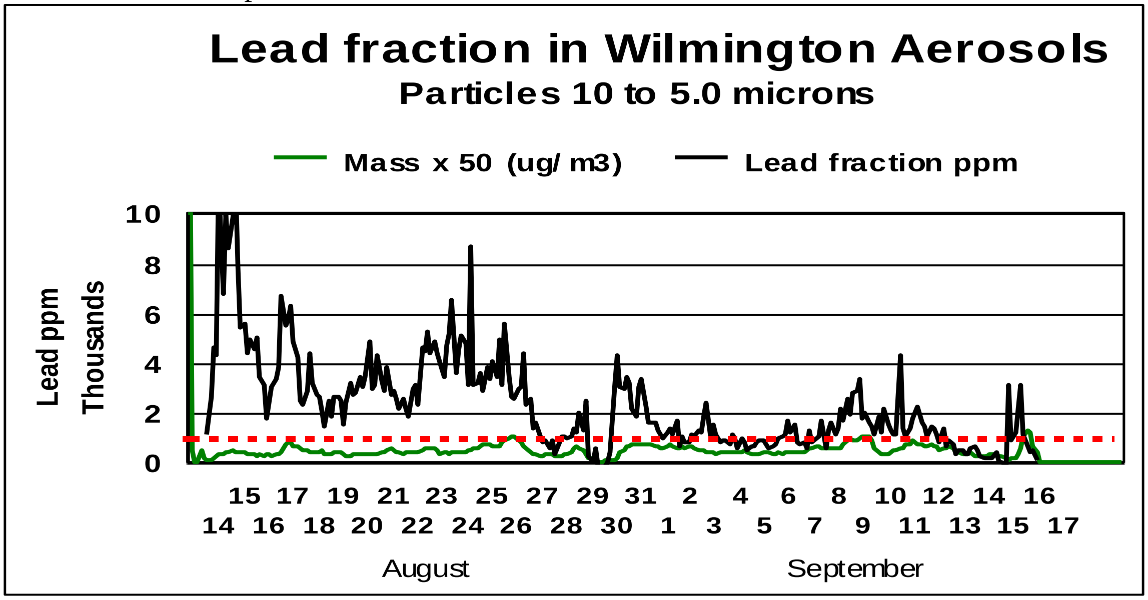
The Terminal Island shredder is the major source of stationary source emissions on the island, with 3.78 tons/year PM_{10}, (Appendix A), which is about ½ the total of all stationary facilities, plus about ½ of the cadmium, lead, mercury, copper and nickel aerosols.

In order to evaluate the impact of these materials downwind in Wilmington, CA, and specifically the deposition of toxic metals onto surfaces and the soil, a study was begun in Summer, 2008 to measure the source materials at the shredder, their transport as aerosols downwind into Wilmington, and their deposition impact onto surfaces including play ground structures. Specifically, the study posed the question of the toxic potential of airborne deposition.

On August 20, 2008 samples were collected from the Terminal Island shredder's pollution reduction system during the execution of a criminal search warrant by DTSC and later analyzed for elemental content by synchrotron-induced x-rat fluorescence (S-XRF) (Appendix C)

Aerosols were collected and analyzed downwind of the Terminal Island car/appliance shredder for mass and elemental content every 3 hrs in 8 size modes (10 to 0.09 µm) over a period of 5 weeks in August and September, 2008, and in 9 size modes (35 to 0.0 µm) over a period of 4 weeks in May and June, 2009. The aerosols measured in 2008, identified as originating from the shredder, contained lead and zinc, with lead averaging 96 ng/m^3 in the 16 major (6 hr duration@) episodes. In addition, an unusual very fine iron aerosol was seen coming from the shredder.

The amount of deposited particles was calculated by introducing the settling velocity (Sehmel, 1981, Seinfeld and Pandis 1997) for the aerosols. DTSC's regulatory thresholds only apply to deposited particles, not aerosols, so the deposition-weighted values are the only relevant ones to compare with DTSC's hazardous waste thresholds. We note that over all hours during the 6 week study the coarse (10 to 2.5 µm) lead values were 2,369 ppm, dominated by the episodes coming from Terminal Island, which averaged 4,446 ppm Pb. The deposited levels of both lead and zinc were in excess of DTSC's hazardous waste threshold limits, 1,000 ppm and 5,000 ppm respectively. Below we show the continuous lead data in aerosols in the size mode that provides 83% of all deposited lead.



Ship activity in the Port of Los Angeles was seen in the sulfur, vanadium, and nickel aerosols from ships in the harbor, with potential health impacts. However, these levels were somewhat less in 2009 than in 2008, perhaps reflecting less ship traffic, less likely due to improvements in emission rates from ocean going ships.

In terms of aerosols tied to the shredder in the 2008 study, measurements in spring, 2009, showed massive reductions in the very fine particles coming from the shredder. Very fine iron was only 9% of the 2008 level, while lead was reduced by 40% from the 2008 values. Further, very fine iron seen in spring, 2009, was usually correlated with activities at the shredder site monitored by video camera, including smoke emissions. Thus, the sharp reductions reflect improvements in the pollution control systems. Coarser aerosols particles were about the same as in 2008 or even slightly higher, likely reflecting resuspension of contaminated soils.

Wipe tests of impervious surfaces were made downwind of the shredder and into the City of Wilmington. These samples were analyzed by S-XRF and showed that the levels of lead and zinc fell off by about a factor of 2 as one moved from near-port sites into downtown Wilmington, (including the fence of a school playground), while still exceeding the lead and zinc DTSC hazardous waste threshold limits.

This report will present each of the periods separately and then perform the comparison study.

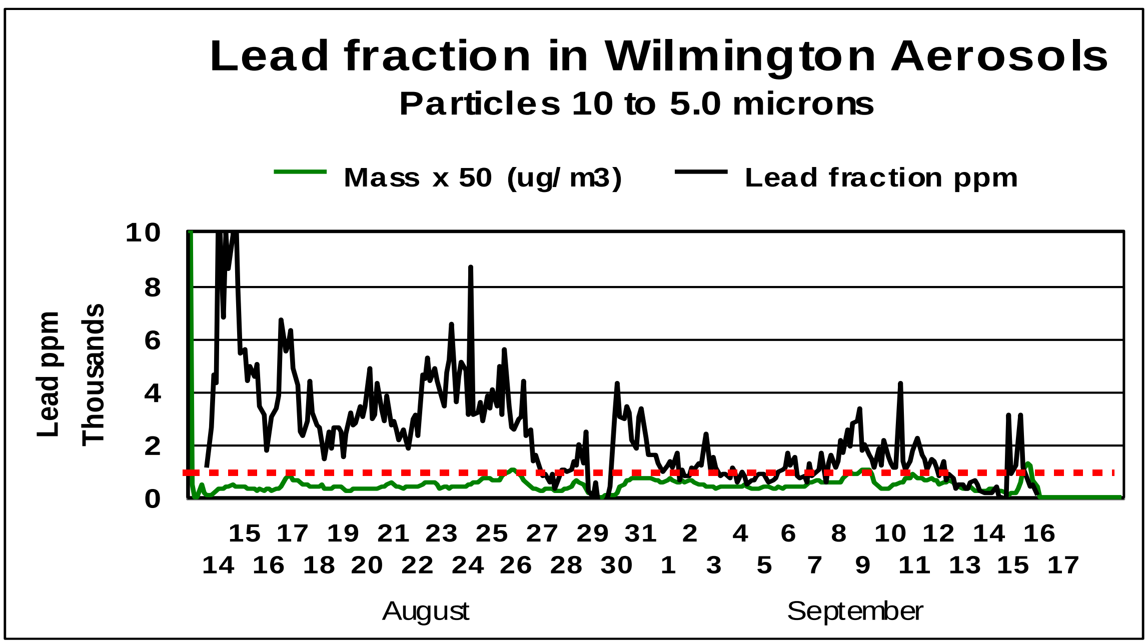
Part 1: Summer, 2008

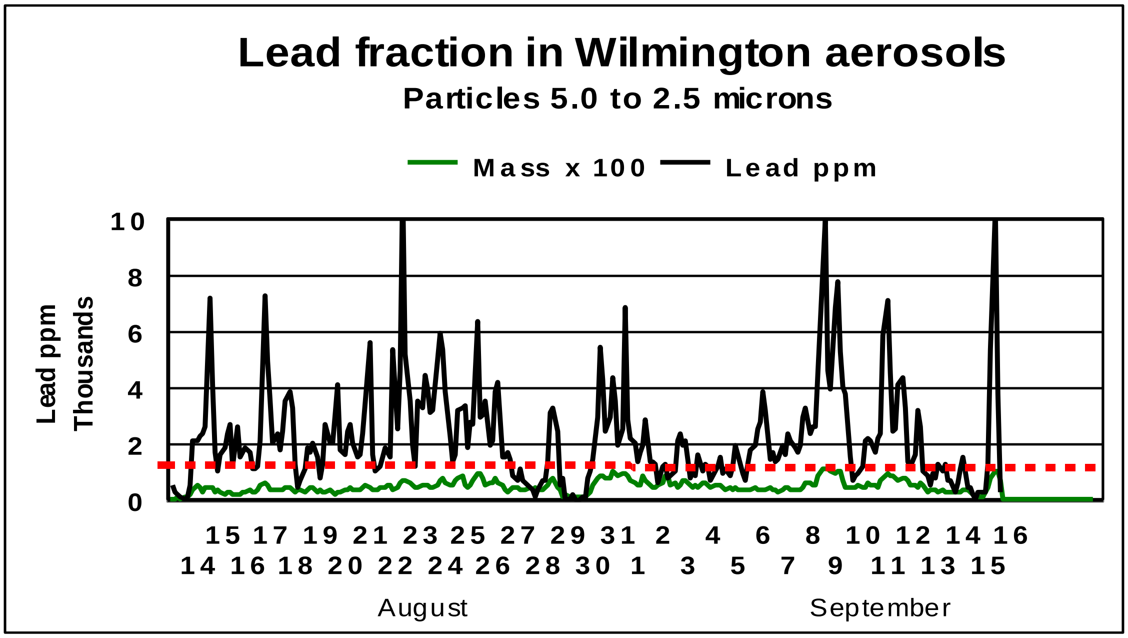
Deposition of coarse toxic particles in Wilmington, CA for the Department of Toxic Substances Control (DTSC) August – September, 2008

Executive Summary – summer, 2008:

Elemental and mass values from the UC Davis DELTA Group 8 DRUM impactor, with DTSC personnel, support, and execution, have delivered unambiguous tracers of the impact of the Terminal Island auto/appliance shredder on Wilmington. These tracers overlap known hours of shredder operation and transport on south winds, and are confirmed by evidence of upwind aerosols from the harbor, including natural sea salt and the vanadium/nickel/sulfur pollution of ocean going ships using bunker oil as fuel.

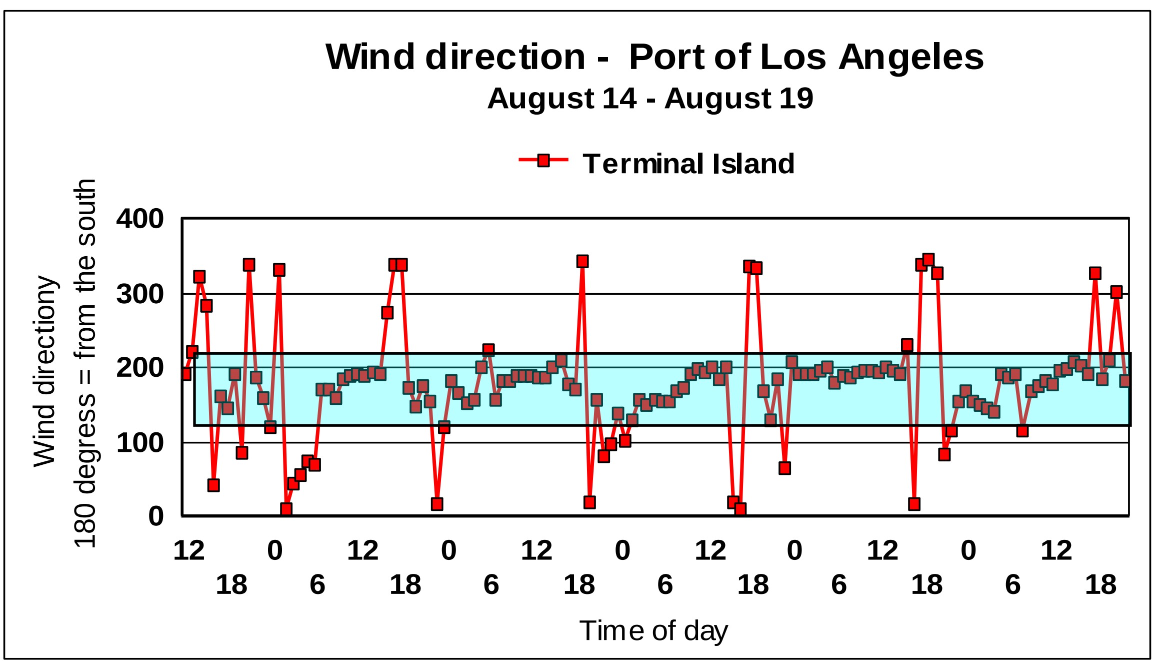
The data indicate the presence of many metals measured at the Wilmington Fire Station 49, including lead, which occur in coarse particles that will readily settle onto the ground. Two examples are shown below, including the 10 to 5.0 μm fraction responsible for 83% of all deposited lead. The DTSC 1,000 ppm lead standard shown below only applies to particles deposited onto surfaces.

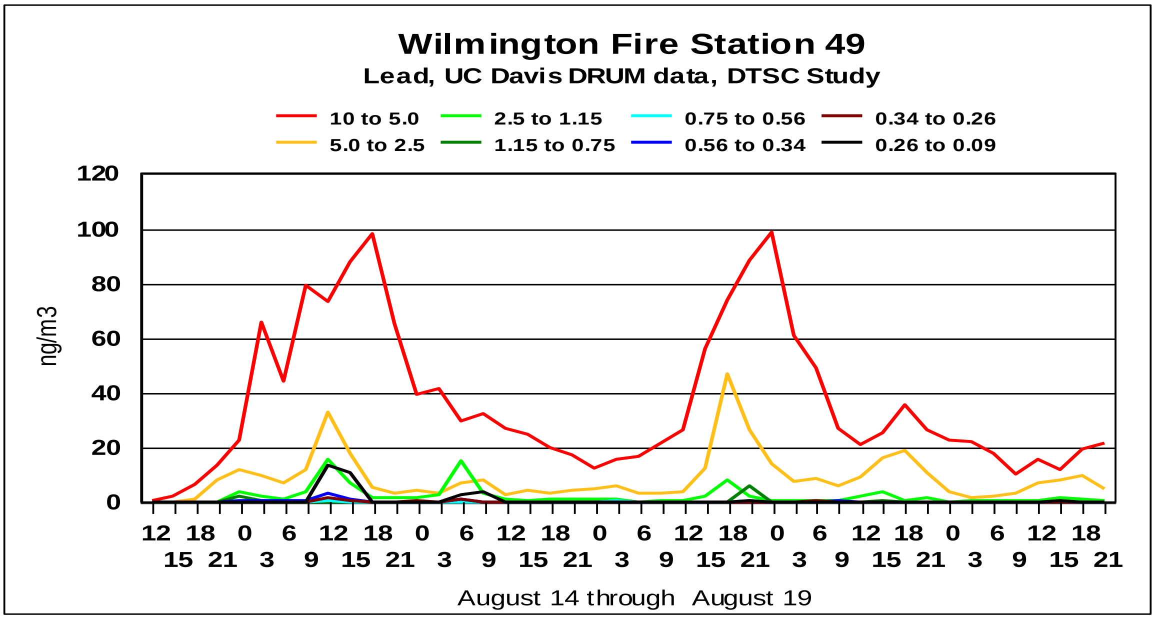




In addition to the coarse toxic elements, the very fine elements from the shredder, especially very fine iron, are themselves in concentrations and particle sizes that are capable of causing health impacts to lungs.

With the availability of local wind data from the LA Port network, it is possible to examine meteorological transport and toxic elements in Wilmington on a 3 hr by 3 hr basis. The daytime wind direction is routinely from the shredder to Fire Station 49, shown below. The aqua range is ± 45 ^{o} around the 160 ^{o} wind trajectory to Wilmington.





The high lead values, as well as iron and other elements, peak when the wind is blowing from the shredder to Wilmington. There also appears to be extensive lead and iron pollution, in the coarsest mode only, of the entire area around the sampling site that may represent prior shredder impacts.

Part 2: Spring, 2009

Deposition of coarse toxic particles in Wilmington, CA for the Department of Toxic Substances Control (DTSC), May – June, 2009, Thomas A. Cahill, Professor of Physics (Recalled), Atmospheric Science and Head, Delta Group, David Barnes, Ph.D., Project Manager, UC Davis DELTA Group, and Kristen Boberg, DTSC

Executive Summary – spring, 2009:

Aerosols were measured in May and June, 2009, at the same site used in the August – September, 2008 study, Fire State # 49 of the City of Wilmington. Guided by the results of the summer, 2008 study, a number of changes were made to reduce uncertainties and better establish rates of deposition of toxic particles:

1) Video monitoring was used to study shredder operations, day and night, with 1 hr time resolution,
2) Aerosol samples were collected from the pollution control system of the shredder to establish potential sources,
3) Aerosol measurements were made at FS#49 with two DRUM samplers.

a. One was identical to the DRUM used in summer, 2008, with 3 hr time resolution and a PM_{10} inlet, and analysis for mass and S-XRF elements, (Mg to Mo, plus Pb, Appendix C),

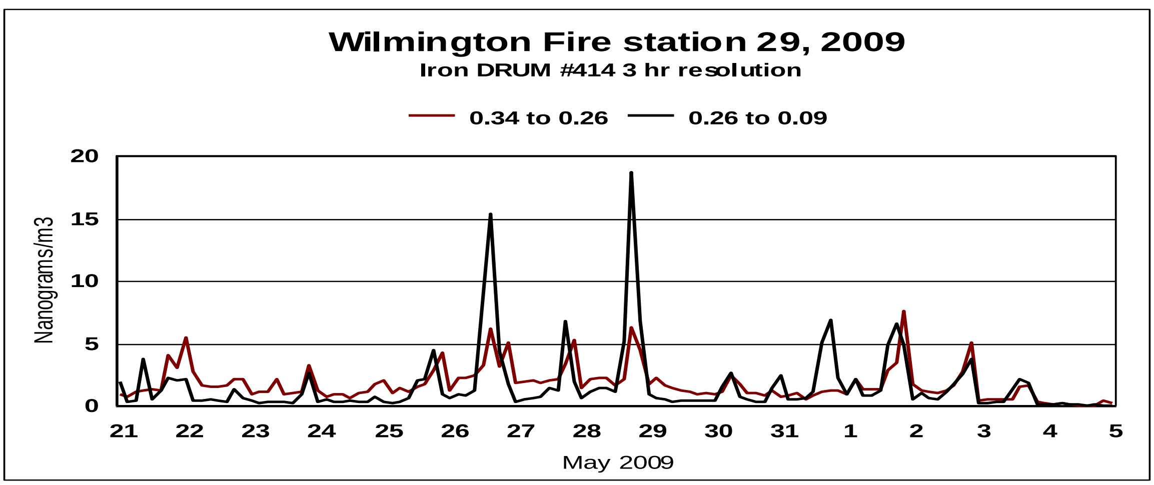
b. The second had a 35 μm inlet and a continuous ultra fine stage, 0.09 > D_p > 0.0 μm stage, with 3 hr resolution, with mass and S-XRF elements,

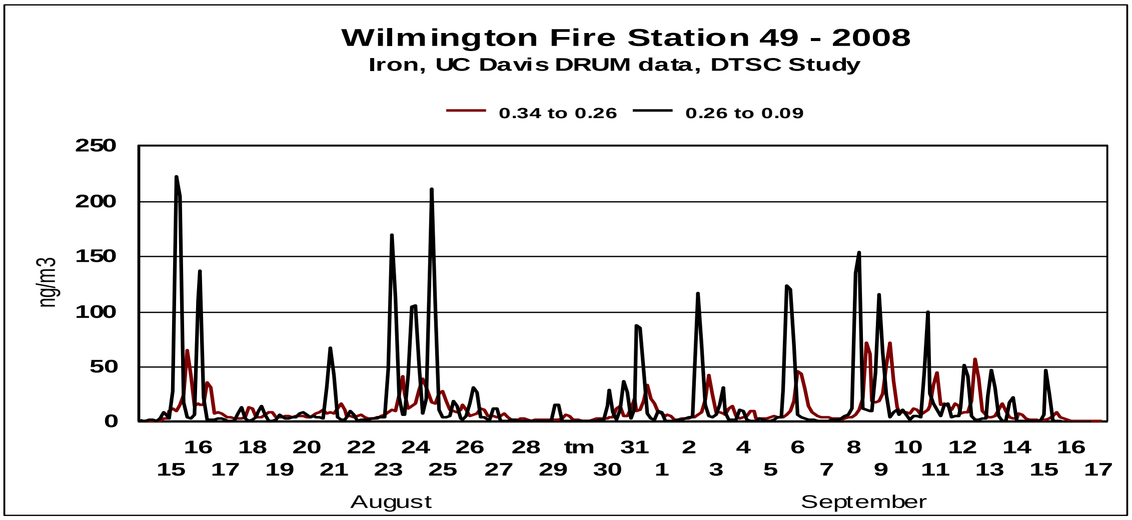
4. A third DRUM sampler was established in downtown Wilmington, with a 35 μm inlet, 3 hr time resolution, mass, and S-XRF elements,
5. Deposition foils were placed from the port to downtown Wilmington to directly measure deposition onto S-XRF analyzable filters,
6. Wipe samples were taken on S-XRF analyzable Teflon filters at sites near the port to downtown Wilmington to examine deposition to impervious surfaces.

Aerosol pollution from ships in the harbor burning bunker oil, traced by vanadium and nickel in the very fine mode, were reduced to 71% of the summer, 2008 values, with possible decreased port operations and/or improved regulations. Very fine sulfur aerosols, with the same ship sources plus diesels, were reduced to only 31% of the 2008 values.

The aerosol results showed that the same aerosols were seen as were observed in summer, 2008, coming from the shredder, confirming the previous association with the shredder but with important differences. The 2009 fine iron and lead were generally associated with smoke observed coming from shredder operations.

Very fine aerosols measured in Spring, 2009, measured much less than in summer, 2008. Specifically, very fine iron was reduced to only 9% of its 2008 value, and lead was reduced to 40% of its 2008 value.





Coarse particles, however, were roughly the same or even slightly higher than in 2008. This is interpreted as a successful reduction of prompt shredder very fine emissions, but continuing problems with mechanical mode particles mixed with soil disturbed land surfaces, exposed piles, shredder operations, etc.

The behavior of the wipe samples shows a progression from high levels for deposited lead and zinc at or near the port, and a fall off by about a factor of 2 as one moves deeper into the community. Other species such as iron show no such variation. All samples were above 1000 ppm for lead and 5,000 ppm for zinc. The E Street School site wipe was taken at the boundary fence of a pre-school play ground.

The deposition samples had a relatively high failure rate, with filters lost to winds, samplers missing, etc, but the method shows promise. The results of the deposition samples show clear input of non-soil iron, plus titanium, vanadium, manganese, and zinc, along with a modest increase in lead.