SULLIVAN ENVIRONMENTAL CONSULTING, INC.
Established 1988

Expert Report - Air Deposition Analysis Related to USMR Smelter Operations in the City of Carteret, New Jersey

On Behalf of Plaintiffs:

Juan Duarte, Betsy Duarte and N.D., infant, by Parents and Natural Guardians Juan Duarte and on behalf of themselves and all others similarly situated

United States Metal Refining Company, Freeport Minerals, Inc., and McMoran, Inc.

Defendants.

2:17-cv-01624-ES-SCM

David A. Sullivan

Certified Consulting Meteorologist #256

May 4, 2019

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Glossary

Annual Average Concentrations: The average air quality concentration during a calendar year.

Background Concentrations: Airborne concentrations that would be expected without the facility under review.

AERMET: A preprocessor that is used to prepare meteorological input data for the AERMOD dispersion model.

AERMOD: An air quality model that is widely used in the U.S. for air quality analysis of airborne concentration and deposition to the surface. This model has been approved by the United States Environmental Protection Agency for lead deposition modeling assessments.

Chebyshev: An optional basis to estimate the 95th percent upper confidence limit of the mean in the ProUCL software.

Compliance Averaging: The 95th percent upper confidence limit of the average contaminant concentration in a functional area is used to determine compliance with remediation standards or the soil cleanup criteria rather than the contaminant concentration of individual samples.

Deposition: The fallout of atmospheric pollutants to the surface. In terms of this report, deposition refers to particulate matter that falls onto buildings, driveways, grass, roadways, and other surfaces, which can be re-entrained into the atmosphere and/or tracked into indoor environments.

Dispersion Modeling: This refers to computer-generated estimates of airborne concentrations and deposition of pollutants to the surface based on a dispersion model and input data such as emission rates from specific sources and meteorological data.

EPA Guideline on Air Quality Models: A document periodically published by the U.S. Environmental Protection Agency to guide the use of air quality models.

Fugitive Emissions: Refers to airborne emissions that are not released from a stack or vent, but more general releases such as through open structures associated with smelter operations.

Functional Area: In New Jersey, a functional area is a fixed area where samples are taken as input to the calculation of compliance averaging. For residential areas, one or two functional areas (such as front yard and back yard) were typically defined.

$g/m^2/year$: Units used to describe the mass deposition of particulates to the surface. Note that the mass unit is 1,000,000 times larger than what is used to display airborne concentrations, which are in micrograms per cubic meter ($\mu g/m^3$).

Gamma Distribution: An optional distribution that can be used in ProUCL as the basis to estimate the 95th percent upper confidence limit of the mean.

Model: An air quality model is a computer program that accepts meteorological data, source location data, and the rate of emission of pollutants to the atmosphere, particle size distribution data, particle density data, and other inputs to then estimate air quality concentrations and deposition to the surface of air pollutants.

NAAQS: National Ambient Air Quality Standards.

Particulate(s): Refers to pollutants that are in particulate form, i.e. solid matter that tends to settle to the surface by gravity and other forces.

ProUCL: A statistical software package developed by the U.S. Environmental Protection Agency and incorporated into New Jersey guidance by reference. ProUCL can be used to compute the 95th percent upper confidence limit of the mean of soil samples collected within a functional area.

Receptor(s): In an air quality model, a receptor is a location where the computer program estimates an airborne concentration or deposition rate. Typically, there are hundreds or thousands of receptors in a modeling analysis.

Recirculation Zone: A location where a pressure drop behind obstacle(s) creates turbulent recirculating flow that can create preferential zones for airborne deposition.

Scenarios [1]: In this report two scenarios were modeled in addition to a base scenario. The base scenario is directly based on previous USMR modeling produced by USMR contractor Dr. George McVehil. Scenario1 uses Dr. McVehil's early operational emissions assumptions for the period up to approximately 1953 and then uses more recent emissions assessment by USMR staff meteorologist Mr. Richard Dunk for the approximate period of 1953 to 1986. Scenario 2 is the same as Scenario 1 except that the cutpoint between the early and more recent period is set to 1970. Scenario 2 was run for purposes that include model sensitivity testing.

TSP: Total suspended particulates, typically defined as particles with diameters ≤ 30 µm.

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[1] In the modeling files the key is as follows: Run 1 = base scenario, Run 2 = Scenario 1, and Run 3 = Scenario 2.

Wind Direction: In meteorology and air quality modeling, wind direction is the direction from which the wind is blowing from.

UCL: Upper confidence limit of the mean of a group of samples, such as from a common functional area, based on statistical testing relative to an assumed distribution.

µg/m^3: Micrograms per cubic meter is a term used to describe the concentration of an air pollutant.

USMR: United States Metals Refining Company, Freeport Minerals, Inc., and McMoran, Inc. i.e. the defendants in this matter.

UTM: Universal Transverse Mercator (map units).

1.0 SCOPE OF ASSIGNMENT

I have been retained by the law firm of Nidel & Nace, P.L.L.C., and German Rubenstein LLP, as an expert witness for air quality / meteorological analysis. I have been asked to evaluate airborne and surface deposition of emissions associated with the operation of the USMR lead smelter in Carteret, New Jersey and Port Reading, New Jersey (see Ref 58:1 for the proposed Class Area map) from approximately (the year) 1902 (Ref 2:1) through the closure of the USMR facility in the year 1986. The modeling analysis was extended into Staten Island, New York to allow for some limited review of model performance based on the available measured soil data and air quality data across the Arthur Kill River in the New York.

2.0 QUALIFICATIONS

I am a Certified Consulting Meteorologist with 44 years of professional experience in air quality / meteorology. I have a Bachelor of Science Degree in Meteorology-Oceanography from New York University (1972) and a Master of Science Degree in Meteorology from Pennsylvania State University (1974). I have been serving as a Certified Consulting Meteorologist since 1980. I have testified as an expert witness on air quality related matters since 1980, including cases specifically related to the movement of heavy metals into surrounding land use areas. My areas of expertise include air quality dispersion modeling (computer-generation of expected airborne concentrations and surface deposition), air quality and meteorological monitoring, exposure assessment, media transfers of airborne pollutants to surface soils and other surfaces and related statistical analyses.

The list of cases where I have testified as an expert witness over the previous four years is as follows:

Palano v AES Corp. (Delaware CC.A. No.: N09C-11-021-JRJ	2015	Dominican Republic
Raymond v. Hostetler	2017	Hotchkiss, CO
Brown et. al., v St. Gobain Performnce Plastics Corp.& Gwenael Busnel 1:16-CV-00242-JL	2018	Merrimack, NH
Hermens v. Textile Coated Incorporated 216-2017 =-CV 00524 & 00525	2018	Manchester, NH
Bell et. al. v WestRock and West Point Chips Case No:3:17-cv-00829 USDC	2018	West Point, VA
Doe Run Peru case	2019	La Oroya, Peru

I have served as Principal Investigator or Study Director for many U.S. Environmental Protection Agency studies of toxic air pollution, as described in my resume (see Appendix A). I also served as Program Manager for the development of air quality modeling systems for projects associated sponsored by the U.S. Environmental Protection Agency. I have performed over 50 air quality / meteorological monitoring studies over the past 20 years primarily to conduct research to estimate airborne emissions from complex area sources associated with agricultural pesticide applications. I have served as the President of Sullivan Environmental Consulting, Inc. since its founding in January, 1980.

3.0 COMPENSATION

Sullivan Environmental Consulting, Inc. is being compensated for the time that I spend, and for staff working under my direction on this case with project rates applicable to the year 2019 in the range of $116.06 to $215.97 per hour. My rate is $215.97 for all work conducted for this matter in 2019, including data evaluation, report preparation, and providing testimony.

4.0 OPINIONS

Based on my training, experience, a site area visit on March 13, 2019, my review of soil contamination, the conduct and interpretation of air quality dispersion modeling, and my review of other available data related to this case, I have formed the following opinions to within a reasonable degree of scientific certainty:

1. USMR operations during the period of greater than 80 years produced air quality impacts and offsite soil contamination well in excess of background levels.
2. Concentrations in the ambient air higher than the 1.5 µg/m^3 ambient air quality standard for lead occurred throughout much of the operational life of the facility and resulted in deposition in area soils.
3. Exposure to carcinogenic air pollutants, such as arsenic, also contributed to environmental risks to the population in the vicinity of the smelter.
4. Deposition of airborne lead, arsenic and other toxic pollutants onto residential properties, parks, schools, and other areas of exposure to the general public created widespread contamination of soils throughout and beyond the proposed class area where children lived and played, and presently are exposed.
5. Review of the soil contamination dataset reveals that the cluster of the highest impacted lead and arsenic soil contamination is generally centered on the USMR facility with general trends of decreasing soil deposition impacts as a function of distance from the facility up to and beyond the proposed Class Area.
6. Heavy metal soil contamination above background levels from USMR operations occurred throughout and beyond the proposed class area.
7. The general pattern of contamination is not consistent with emissions that would be expected from leaded paint, leaded gasoline, pesticide use, slag, or other potential source categories.
8. There was no industrial facility other than USMR that could match the observed magnitude of impact and pattern of soil contamination as demonstrated by the soil data.
9. The removal of "outliers" associated with the soil samples was performed without confirmatory follow-up that these samples were either invalid or part of a different population not associated with airborne deposition. High levels of scatter within general trends are typical of soil contamination associated with the air deposition pathway. There is no explanation in the comment column for removing outliers based on documentation that such samples were associated with another statistical population, nor have I seen any

laboratory documentation that supports the removal of outliers because they were analytically invalid samples. With highly skewed distributions associated with airborne deposition patterns, the removal of high values as done by the Defendants is not appropriate, and more importantly, the removal of the high value (high soil concentration) samples was not protective of human health. It is my opinion that all of the data eliminated from further analysis as "*outliers*" should be reassessed to confirm that sufficient remediation was performed to protect public human health and welfare.

10. Compliance averaging can allow "*hotspot*" areas with lead and arsenic contamination to remain in place after the proposed remediation is completed as well as fail to trigger remediation, which results in leaving hotspots in place.

11. The modeling of the USMR-generated stack and fugitive facility related emission rates, such as shown in Scenario 1, reasonably replicates the general trends and magnitudes of the measured soil contamination as well as the limited air quality data. Because of poor maintenance of failed operation of control equipment, numerous violations of permit conditions and incomplete coverage of sources, it is my opinion that the actual impacts from USMR operations are higher than those shown in the modeling results.

12. The surface soils, such as the top centimeter, are the primary point of contact in terms of human exposures. Based on the central tendency of the soil profile data, it would be expected that the actual lead and arsenic contamination in the near surface soils would be higher than the composite zero to six-inch samples collected and analyzed by USMR.

13. Ratios of soil concentrations in the top six inches of the soil profile … ratios of copper to arsenic, lead to arsenic, and lead to copper generally approach background levels as distance from the USMR smelter increases, which is indicative of impacts from the USMR smelter and associated USMR facility operations.

14. All of the properties within the proposed class area were blanketed with over 80 years of airborne deposition of lead, arsenic, and other particulate matter emitted by the USMR facility. These impacts produced soil contamination levels well above background throughout the proposed Class Area and beyond. On this basis, a property-by-property analysis is not needed to show whether or not each property was affected by the USMR

facility. This airborne migration pathway of metals from smelter to impacted areas (soil, in Carteret) was caused by airborne emissions from the smelter depositing into soil in a contiguous area (the proposed Class Area).

5.0 BASIS FOR OPINIONS (BASED ON REVIEW OF RECORDS)

The USMR smelter stack(s) and fugitive emissions related to facility operations on the property previously operated by USMR in Carteret, NJ in terms of full scale operation primarily occurred from the years of 1907 to 1986 in the city of Carteret, NJ with initial operations related to significant emissions beginning as early as the year 1902 (Ref 2:1). The location of the facility was located just west of Staten Island, (NY) along the Arthur Kill River. Section 5.1 of this report provides a brief summary of the air quality related matters associated with this facility prior to the closure of the facility in the year 1986.

5.1 Overview of Stack and Fugitive Emissions

The emission rates that are shown in Section 6.1 are based on available data from USMR documents for selected periods. The emission rates are applicable to normal operating conditions as documented by USMR staff and contractor to USMR. An important factor, however, is the fact that there were numerous violations of the USMR facility permit conditions, which led to emission limit violations. As described in (Ref 30:20) by the New Jersey Department of Environmental Protection: "*USMR has a long history of violating the Air Pollution Control Act*." On this basis, it is logical to conclude that modeling of the permitted emission rates will generally tend to understate the actual long-term airborne concentrations and deposition rates. Examples of this are detailed in (Ref 30:20-21) [2] which is displayed below:

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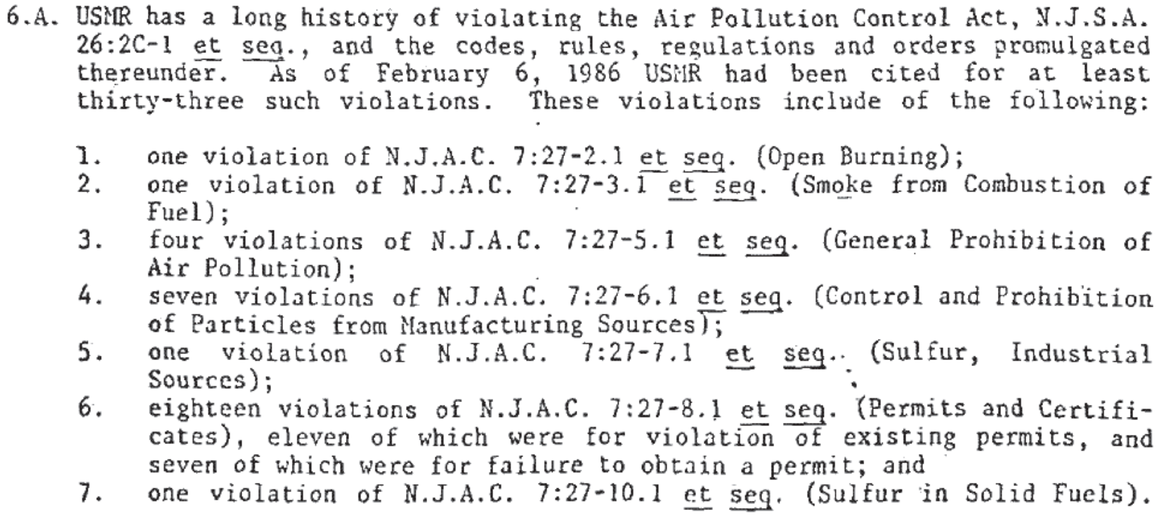
[2] The listing of references in this report uses the following convention. (Ref 30:20) refers to the electronic file in the reference subdirector as (Ref 30; 20 refers to the electronic page number of Ref 30).



6.A. USMR has a long history of violating the Air Pollution Control Act, N.J.S.A. 26:2C-1 *et seq.*, and the codes, rules, regulations and orders promulgated thereunder. As of February 6, 1986 USMR had been cited for at least thirty-three such violations. These violations include of the following:

1. one violation of N.J.A.C. 7:27-2.1 *et seq.* (Open Burning);
2. one violation of N.J.A.C. 7:27-3.1 *et seq.* (Smoke from Combustion of Fuel);
3. four violations of N.J.A.C. 7:27-5.1 *et seq.* (General Prohibition of Air Pollution);
4. seven violations of N.J.A.C. 7:27-6.1 *et seq.* (Control and Prohibition of Particles from Manufacturing Sources);
5. one violation of N.J.A.C. 7:27-7.1 *et seq.* (Sulfur, Industrial Sources);
6. eighteen violations of N.J.A.C. 7:27-8.1 *et seq.* (Permits and Certificates), eleven of which were for violation of existing permits, and seven of which were for failure to obtain a permit; and
7. one violation of N.J.A.C. 7:27-10.1 *et seq.* (Sulfur in Solid Fuels).

Violations of USMR operations included:

- Opacity violations (visible emissions) from process fugitive operations.
- Operating with broken bags on the cupola baghouse.
- Operating the cupola with the fugitive control system not functioning.

There are sufficient emissions data estimated by USMR staff and USMR affiliated consultants to estimate airborne concentrations and deposition of heavy metals for the early, middle, and later time periods of facility operation. These analyses provide a reasonable range in general magnitudes of emission rates and also reasonably represent the spatial trends in the measured data. In my judgment, the modeling on this basis is based on lower than actual emissions because of the history of failing equipment and the lack pollution control maintenance, non-compliance with the permit conditions, and other upsets and conditions that exceed the presumed bases for typical emission estimates. With this limitation in mind, modeling is useful to demonstrate the general magnitude and pattern of expected airborne concentrations and metal deposition impacts over time associated with the operations of the facility.

5.2 Air Quality Monitoring

Air quality measurements were not taken until late in the operational life of the smelter, i.e. the third quarter of 1984 through the first quarter of 1986. The first hi-volume samplers were installed in July 1984 (Ref 30:18). There were four monitors in New Jersey in relatively close proximity to the USMR facility and another monitor on the west side of Staten Island positioned approximately 135 degrees and approximately 1200 m from the location of the smelter (Ref 20:7). According to (Ref 11:50), the Rossville (Staten Island) monitor was specifically located at the NYNEX yard. Figure 1 shows the approximate locations of these monitors. Measured concentrations were listed in (Ref 20:9) and are presented in Table 1.

Figure 1: Location of Air Quality Monitors (Ref 11:51)

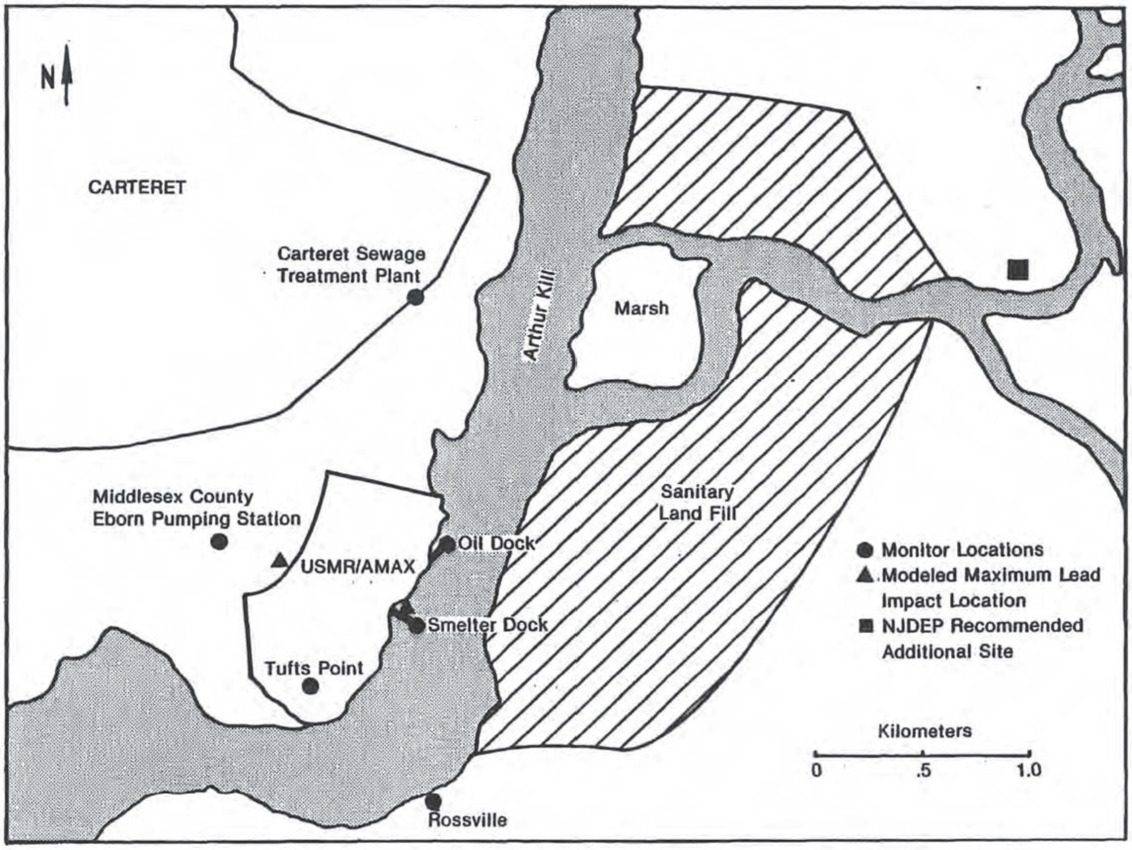


Figure 5-1. Location of Lead Monitoring Sites and Modeled Locations of Peak Off-Plant Lead-in-Air Concentrations at the USMR/AMAX Plant in Carteret, New Jersey

Table 1: Measured Air Quality per (Ref 11:55)

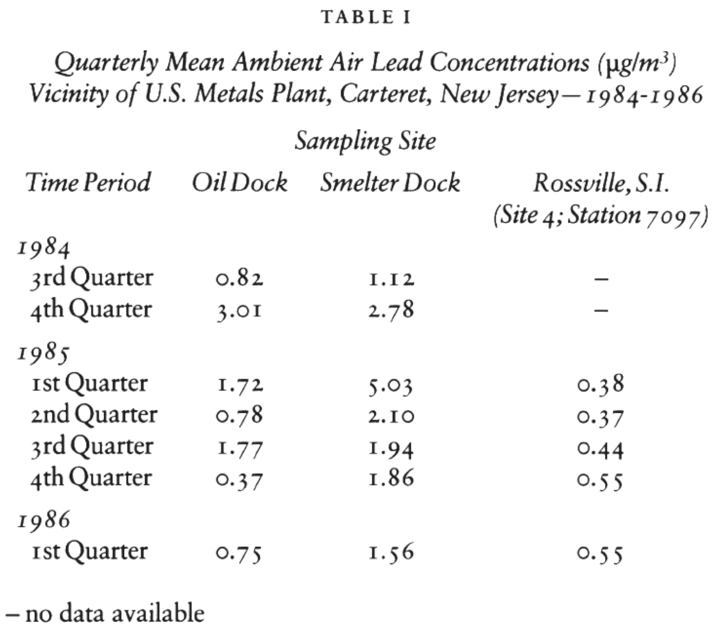


TABLE I

Quarterly Mean Ambient Air Lead Concentrations (µg/m³)
Vicinity of U.S. Metals Plant, Carteret, New Jersey—1984-1986

	Sampling Site		
Time Period	*Oil Dock*	*Smelter Dock*	*Rossville, S.I.* *(Site 4; Station 7097)*
1984			
3rd Quarter	0.82	1.12	–
4th Quarter	3.01	2.78	–
1985			
1st Quarter	1.72	5.03	0.38
2nd Quarter	0.78	2.10	0.37
3rd Quarter	1.77	1.94	0.44
4th Quarter	0.37	1.86	0.55
1986			
1st Quarter	0.75	1.56	0.55

– no data available

As noted in (Ref 30:6), the average airborne lead concentration at the Eborn Pumping Station air monitoring site in the year 1986 (based on the 3rd and 4th quarters and excluding 10/13/1986 and 10/16/1988 outliers[3]) was 0.37 µg/m³. The Tufts Point air monitoring site (in the year 1986) had an average airborne lead concentration of 0.34 µg/m³ based on the 3rd and 4th quarters. These samples range at approximately airborne lead background levels (Ref 11:21), which represent concentrations during the plant closure period.[4]

As noted by Radian in (Ref 30:86), the first quarter of the year 1985 shows high violations of the NAAQS for lead at the smelter dock monitoring site. (Ref 30:86) notes that these high values are likely due to "*non-uniform or upset operating conditions at the plant*." Based on the plant

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[3] Investigation indicated that localized sand blasting produced anomalous sample results for these two days. Based on this documentation these two samples were appropriately supported as outliers and excluded from further analysis. In other words, these two samples were not from the same population of air quality impacts associated with USMR emissions and general background concentrations.

[4] (Ref 56:5) shows shutdown operations started in September 1986.

history, however, substantial diversions from normal operating conditions occurred at other times during the operational life of the facility (Ref 30:20-21). Radian based the average for the year 1985 based on the first three quarters of data, showing a modeled value of 1.7 and measured concentration of 2.0 µg/m^3. The actual annual average measured concentration at the smelter dock for the year 1985, however, was 2.7 µg/m^3, which is 60 percent higher than Radian's modeled annual average concentration. It also should be noted that quarterly averages (not annual averages) were the basis for the National Ambient Air Quality Standard for lead and this standard was in place during the last decade of operation of the UMSR facility.

For perspective, it is important to note that as of the second quarter of the year 1985, smelting operations were trending downward in terms of production (Ref 30:86). Note that based on the above data, (especially at the Rossville monitoring site) the background concentration of 0.55 µg/m^3 was used by Radian (Ref 11:21) and adopted in this report as a default. I expect that the actual background concentration for lead at this location in the mid-1980s was lower than 0.55 µg/m^3 based on the measured airborne lead concentrations at the Tufts Point and Eborn Pumping Station monitoring sites during the Fall and Winter of 1986 when USMR operations were in the process of closing down emission related sources.

5.3 Soil Monitoring

Soil cores were taken on numerous private properties and public areas by USMR. Typically, core samples were taken with samples collected at the depth of: 0-6 inches, 6-12 inches, 12-18 inches, and 18-24 inches (deeper when deemed necessary). Laboratory analysis was then performed for soil lead, arsenic, and copper soil concentrations.

The TIA online database was accessed and the soil levels of lead, arsenic, and copper at each residence were sorted in order to determine the median soil levels of lead, arsenic, and copper at each residence. These data were further processed as a function of distance from the smelter using geocoding coordinates in conjunction with distance from the approximate location of the USMR smelter (approximate location based on aerial overlays) in order to determine the ratios of lead, arsenic, and copper at various distances from the approximate location of the USMR smelter.

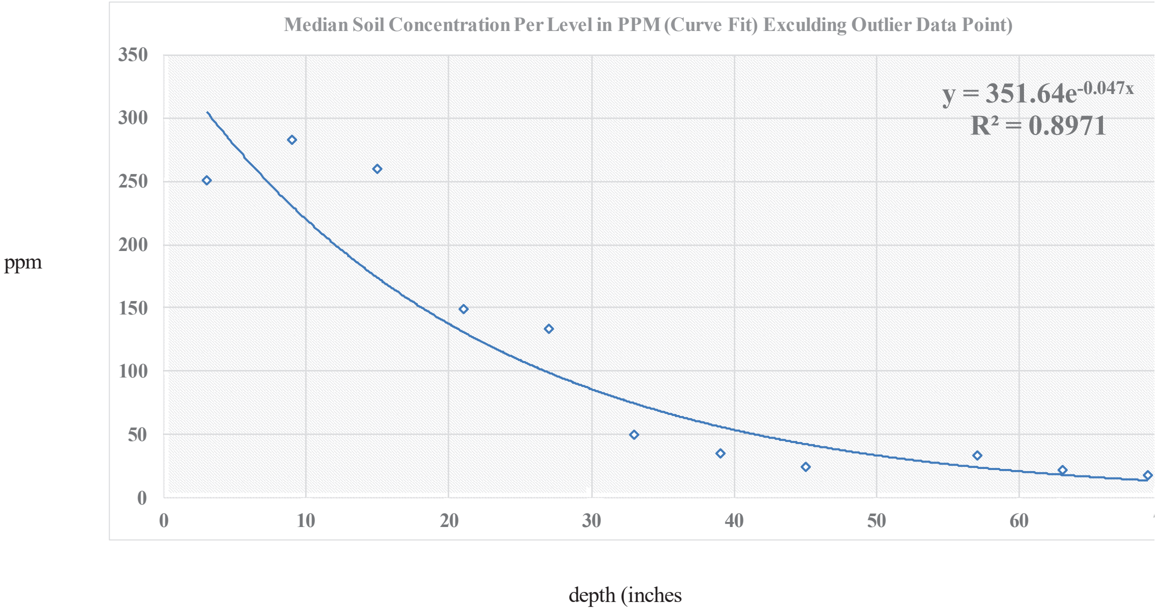
The measured contamination of heavy metals is generally consistent with deposition of airborne lead from the USMR smelter. There is a general trend in terms of decreasing lead soil concentrations with distance from the facility, with typical scatter in terms of median concentrations, which is expected for airborne deposition on a spatial basis within a suburban environment such as in the region of Carteret, New Jersey (and surrounding areas).

An analysis was done based on the median yard concentrations as a function of soil depth. Based on the composite data set, the following relationship between profile depth and lead concentration (ppm) was found using an exponential fit (see Eq. 1).

$$\text{Soil lead concentration (ppm)} = (351.64)\,(e^{-0.047x}) \quad \text{[Eq. 1]}$$

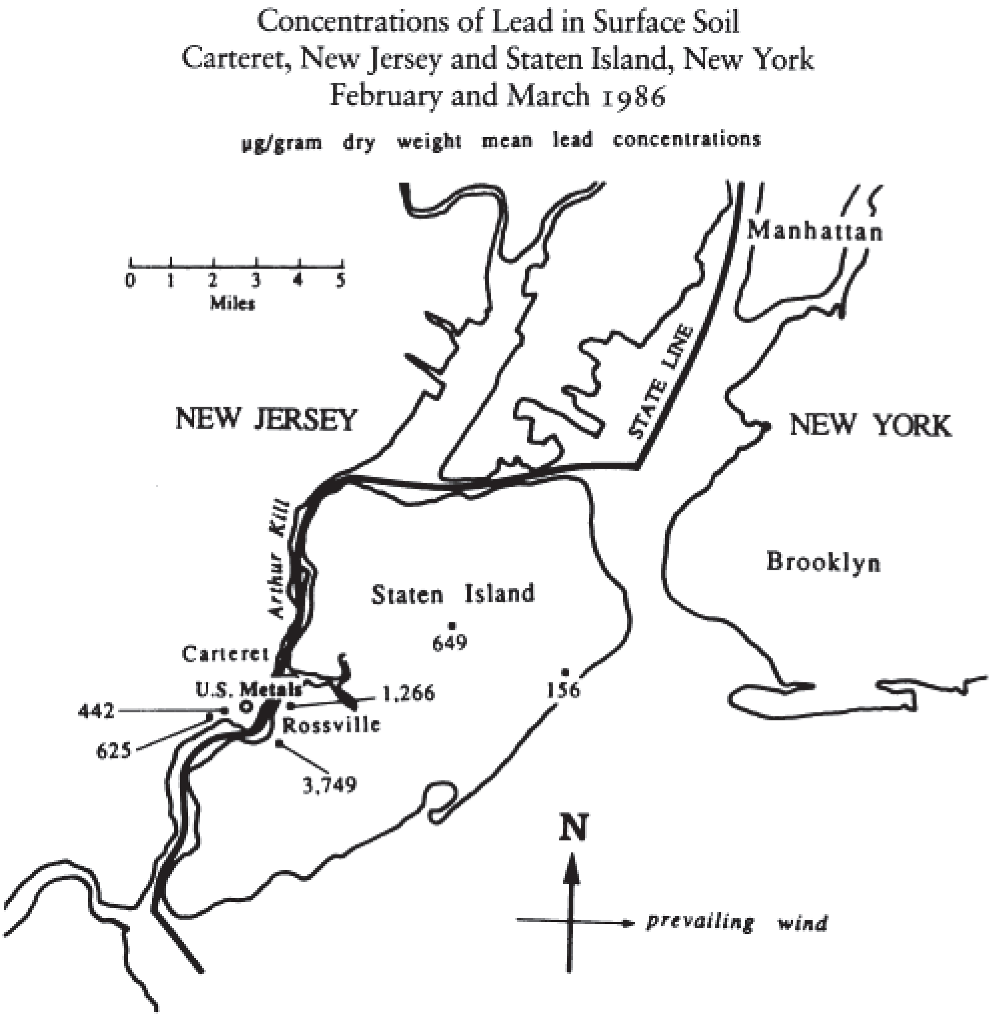
Figure 2 graphically depicts the exponential fit. Through integrating this function from zero to 6 inches (in the soil) compared to zero to 72 inches, it was found that approximately 25 percent of the deposited lead was contained in the top 6 inches of the soil profile. On this basis, only 25 percent of the deposited lead was distributed to the top six inches of the soil profile in the modeling of near-surface (0-6 inches) contamination.

Figure 2: Exponential Fit of Soil Lead Concentration (ppm) As a Function of Soil Depth Based on the Median Concentrations by Depth across the Properties in the TIA Database



Although a much smaller data set, soil lead samples also were taken in the Rossville area of Staten Island, which represents the closest residential exposures to the USMR emissions in Staten Island. The location of these sampling sites is shown in Figure 3.

Figure 3: Staten Island Monitoring Locations and Measured Soil Concentrations (Ref 20:8)


Concentrations of Lead in Surface Soil
Carteret, New Jersey and Staten Island, New York
February and March 1986
µg/gram dry weight mean lead concentrations

The measured soil concentration of 1,266 (ppm) represents the average of four sampling sites in the Sleight Family Graveyard located in Rossville, New York residential areas. The median soil lead concentration is 1,058 ppm The soil lead concentration listed as 3,749 (ppm) in Figure 3 represents the average of six samples taken in residential areas of Rossville, New York, which is the closest residential area to the USMR smelter in Staten Island. The median lead concentration of these samples is 786 ppm (note that one of the samples had a value of 15,800 ppm and another had a value of 4,240 ppm, which skewed the average well above the median). Note that the NYNEX yard where the air quality sampling was conducted in the years 1985 and 1986 is close to the soil concentration of 3,749 ppm that is shown in Figure 3.

Figure 4: Sleight Family Graveyard

Figure 5 shows the Rossville (Staten Island) neighborhood as of March 13, 2019, which is representative of housing in the general area of the 3,749 ppm soil lead concentration shown in Figure 3.

Figures 6 through 8 show the relationship between metal concentration (lead, arsenic, and copper) in the top 6 inches and distance from the USMR smelter. The black triangle in these figures shows approximate location of the USMR smelter when the facility was operational.

Figure 5: Rossville Neighborhood (March 2019)

Figure 6: Median Soil Concentrations in the Top Six Inches for Lead (ppm)

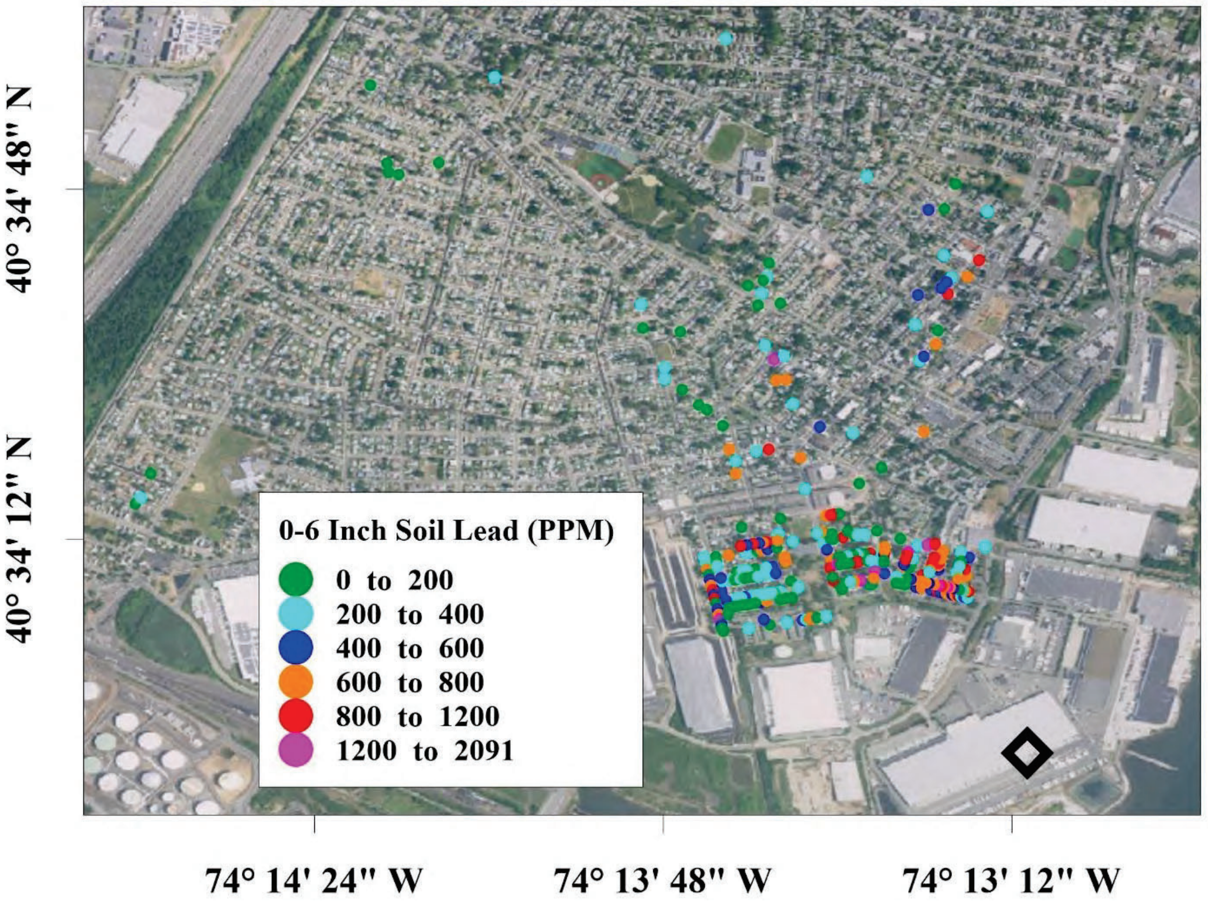


Figure 7: Median Soil Concentrations in the Top Six Inches for Arsenic (ppm)

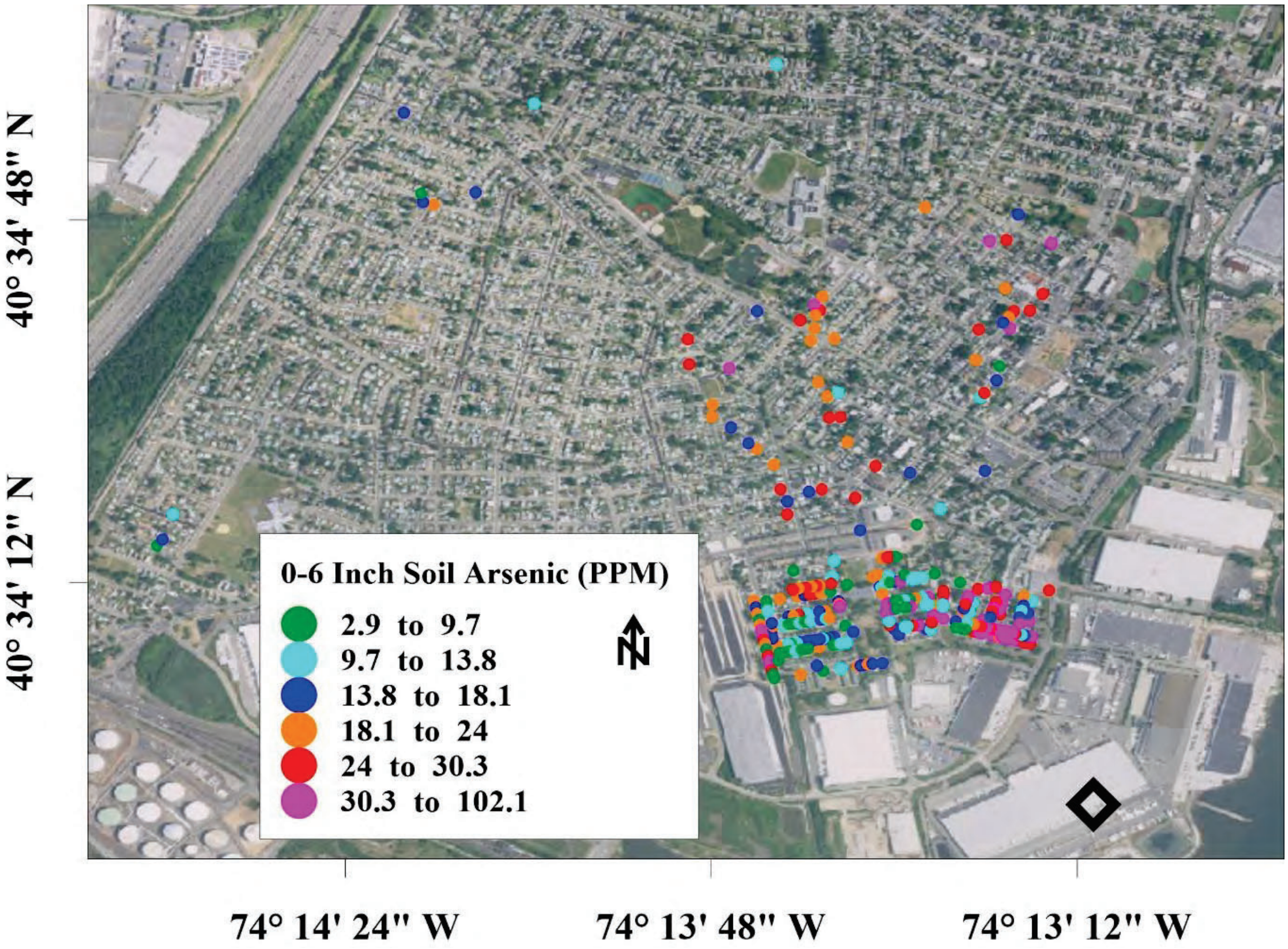
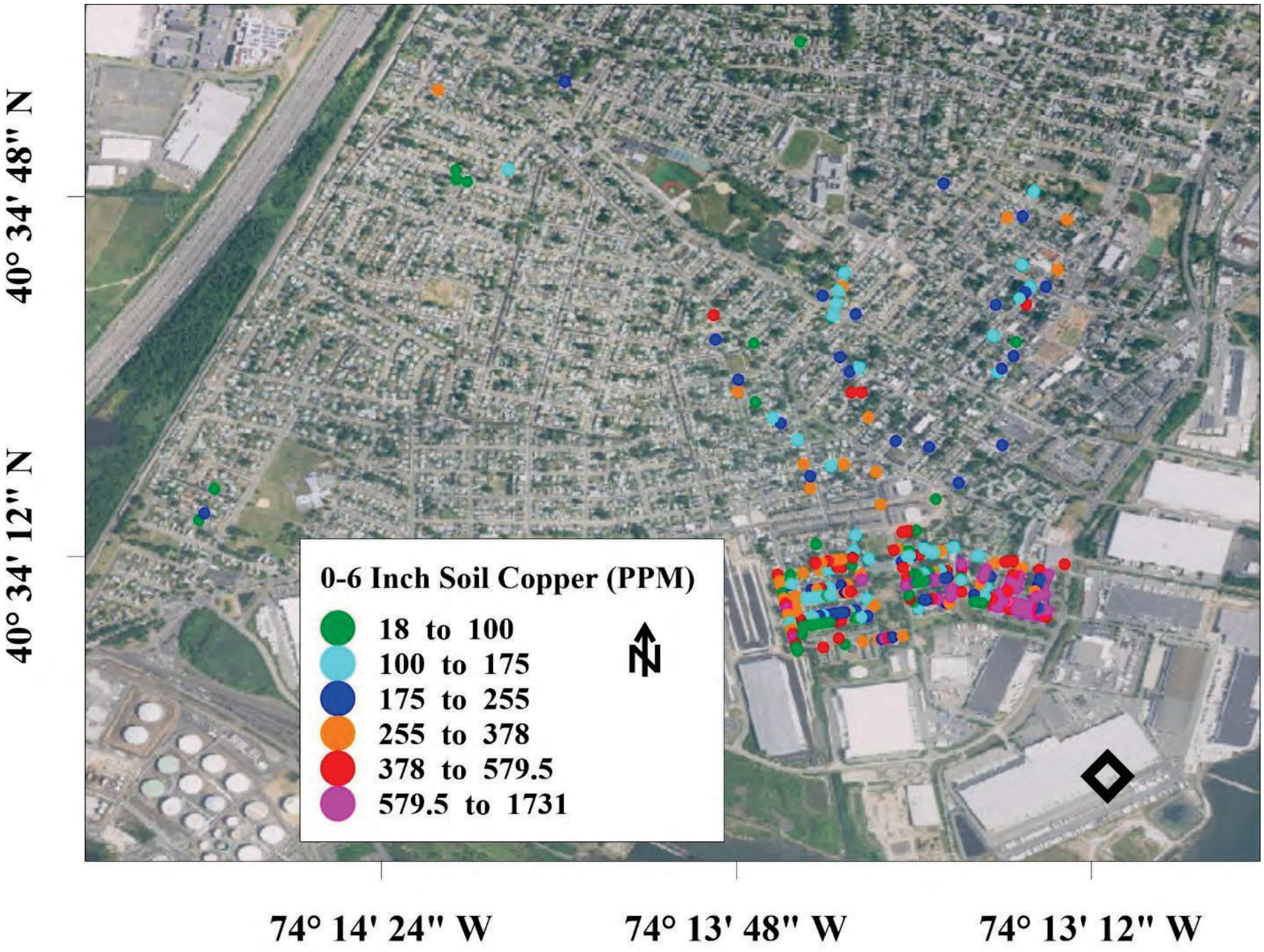


Figure 8: Median Soil Concentrations in the Top Six Inches for Copper (ppm)



5.4 Ratio Analysis

Based on (Ref 34:40) (suburban and urban Sites 37 and 38 in Middlesex County, New Jersey), the average background ratios of lead to arsenic, lead to copper, and copper to arsenic are as follows:

Metals	Background Ratios
Lead/arsenic	62.3/7.5 = 8.3
Lead/copper	62.3/29.3 = 2.1
Copper / arsenic	29.3/7.5 = 3.9

Figures 9-11 show the ratios of lead to copper, copper to arsenic, and lead to arsenic based on data provided in the TIA online database as well as data provided by Chris Nidel. As shown, the ratios generally approach the background ratios as the distance from the smelter increases.

Figure 9: Ratios of Lead / Arsenic Concentrations in the Top Six Inches of Soil as a Function of Distance from the Smelter

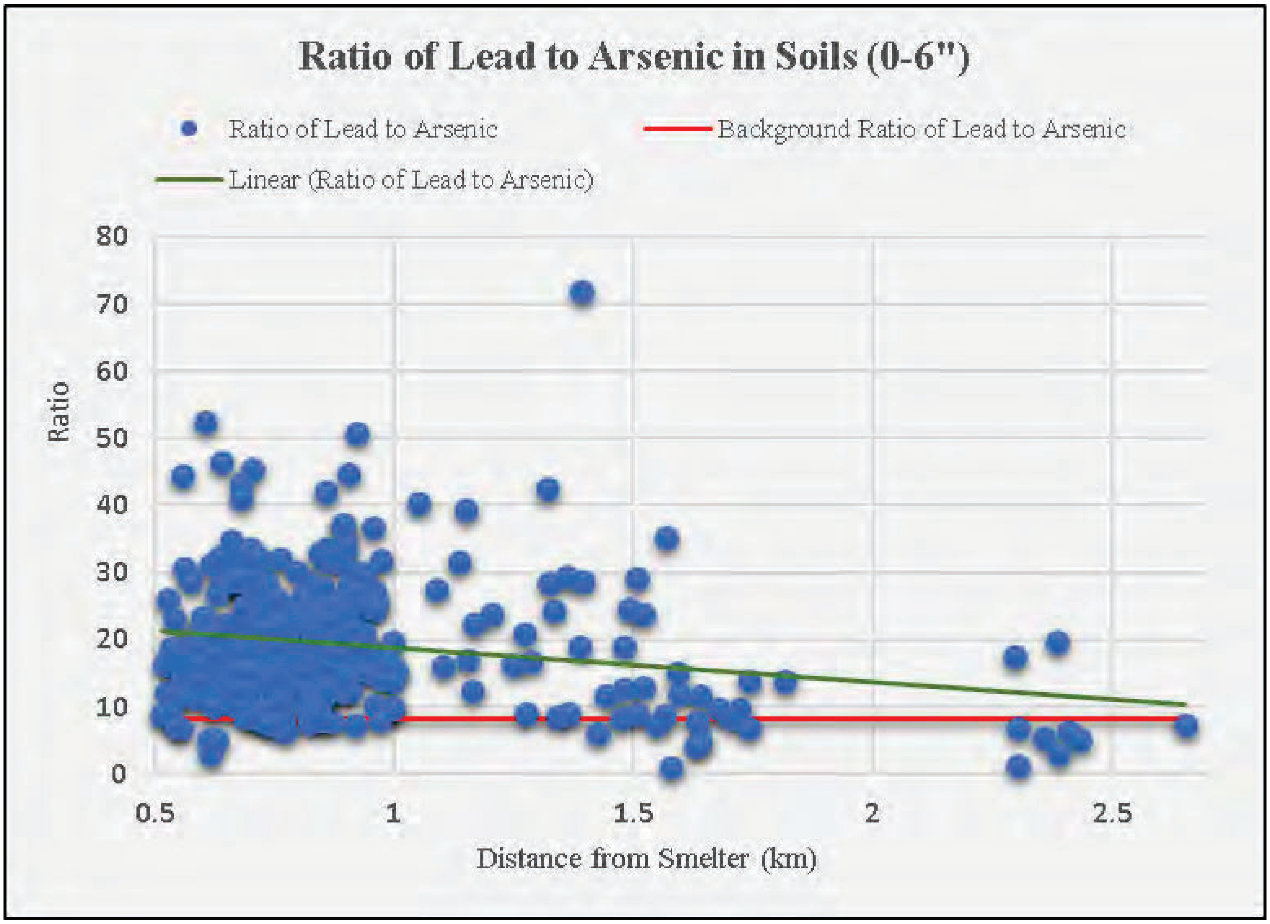


Figure 10: Ratios of Copper / Arsenic Concentrations in the Top Six Inches of Soil as a Function of Distance from the Smelter

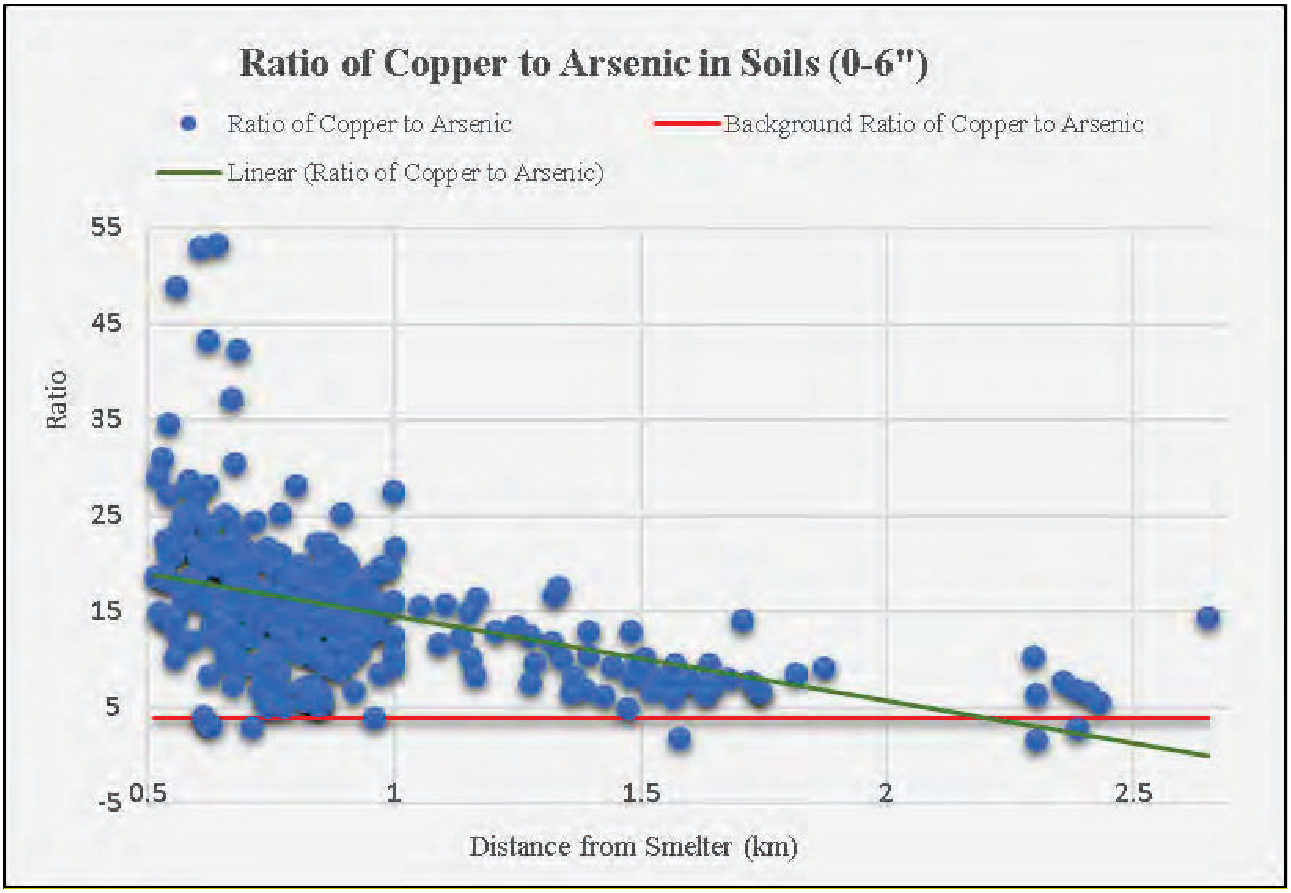
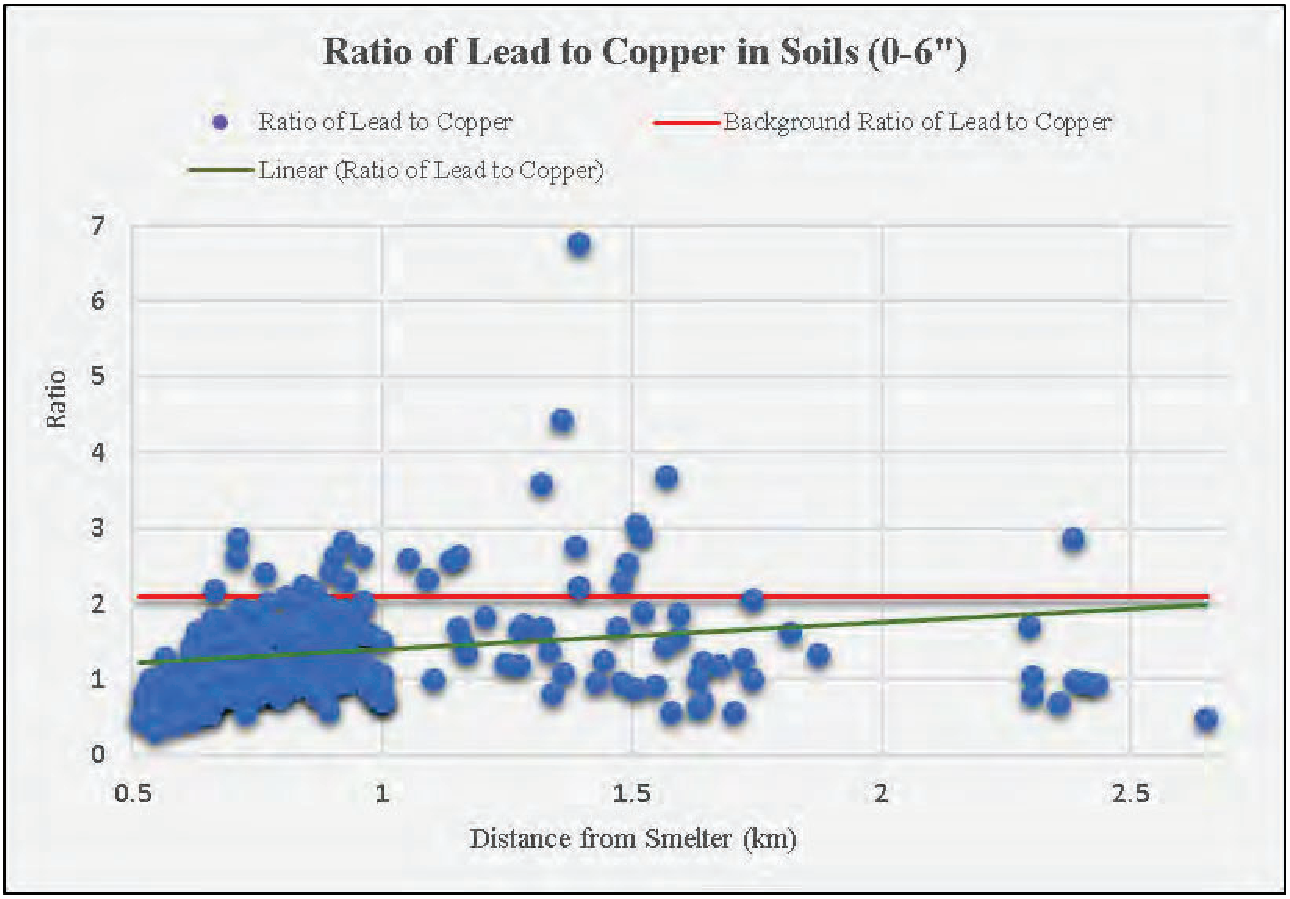


Figure 11: Ratios of Lead / Copper Concentrations in the Top Six Inches of Soil as a Function of Distance from the Smelter



6.0 BASIS FOR OPINIONS (MODEL-BASED EVALUATION)

6.1 Emissions Assessment

The following tables summarize key sources that were modeled by USMR consultants (Dr. George McVehil in consultation with USMR staff) and USMR staff (Mr. Richard Dunk, CCM). I have relied on their emissions data (Dr. McVehil for the earlier time periods) and Mr. Dunk for the more recent time periods. The emissions and release specifications are organized by modeling scenario to provide a clear link to the modeling scenarios. All of the emission rates are linked to USMR's own (employee or contractor) estimates and based on multiple lines of evidence are believed to underestimate true emissions. These emissions data provide examples of emission rates for the early operational period (years 1907 to 1948), mid-range emission rates for the period of years 1948 to 1981, and the lowest emission rates for the period applicable to the years 1982 to 1986 prior to the closing of the facility, which are attributed to the increased pollution controls that were put into place in response to environmental enforcement. What is clearly evident from the emissions data that follows is that a large quantity of heavy metals were released into the air in the vicinity of the smelter which impacted[5] the proposed class area for approximately over 80 years and produced soil contamination above background levels throughout and beyond the proposed class area.

The modeling run described as the Base Scenario is based in terms of input parameters (fugitive and stack emission rates) on the analysis conducted by Dr. McVehil's (the modeling simulation and analysis of facility operations which incorporated the primary stack and fugitive sources related to USMR operations from the years 1907 through 1986. I am using the emissions and stack specifications that he used to model deposition rates. Dr. McVehil modeled deposition to the surface in g/m^2 over specific time periods. I am estimating soil ppm of lead concentration based on an assumed soil bulk density of 1.34 g/cm^3 (Ref 53:1) assuming 25 percent of deposited lead remains in the top 6 inches, and a lead background concentration in the soil of 62 ppm, which is the average of two soil samples collected in Middlesex County, New Jersey (Cranbury

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[5] An alternative description in Ref 59:35 was "*blanketing*" the neighborhood.

listed as a suburban site with 58.9 ppm of lead, and New Brunswick listed as an urban site with 65.7 ppm of lead (Ref 34:40)). It should be noted, however, that: *"The level of contaminants measured in the homogenized twelve-inch core samples for this study may represent a lower average concentration in comparison to surface contamination resulting from atmospheric deposition* (Ref 34:8). It also should be noted that if a higher soil background were to be assumed, the modeled soil concentrations would increase by the same amount. Table 2 summarizes the emissions and stack specifications used in the modeling assessment that was conducted by Dr. McVehil.

Table 2: Dr. McVehil's Modeling Assumptions (Ref 15:1, Ref 21:1) As Used in Base Scenario

Stacks

Stacks							
	time step	g/sec	height (m)	Temp (k)	m/sec	dia (m)	Ref
Cupolas early	1925-1961	192.5	30.5	425	8	4.5	21:01
cupola late	1962-1986	3.883	76	425	8	4.5	15:01
converter original	1906-1953	70.8	30.5	435	7	4	21:01
converter late	1954-1986	17.6	128	435	7	4	15:01

Fugitives

Fugitive Source	Period	g/sec	Reference
Cupola / reverb fug. early	1906-1952	6.49	21:01
Cupola/reverb Fug late	1953-1986	2.65	15:1
Converter fug.	1906-1952	9.72	21:01
Converter fug.	1953-1986	4.30	15:1
Sinter fug.	1915-1935	0.23	21:01

The modeling simulation described as Scenario 1 in this report relies on Dr. McVehil's analysis through the year 1948, but then relies on estimates done by Mr. Dunk for the years 1949 through 1986. Since Mr. Dunk had access to direct emissions and stack specifications data at least for the (years) 1970s and 1980s, his analysis of the later time period is based on more site-specific data than the data that was apparently available to Dr. McVehil, including site-specific emission rates for the fugitive sources based on site-specific monitoring conducted by Mr. Dunk in the late 1970's. Stack and fugitive emissions and source specifications (the model inputs), as incorporated into the Scenario 1 AERMOD modeling simulations, are summarized in Table 3.

Table 3: Emission Rates and Assumed Stack Specifications for Scenario 1 [6]

Stacks

	Time Step	g/sec	Height (m)	Temp (k)	m/sec	Dia (m)	Reference
Cupola Stack	1907-1947	192.48	60.96	425	8	4.5	21:01 & 2:01
Cupola Stack	1948-1981	3.67	76	402	20	3.54	10:14
Cupola Stack	1982-1986	0.81	76	400	20.1	3.54	3:03
Converter Stack	1907-1947	70.83	60.96	435	7	4	21:01 & 2:02
Converter Stack	1948-1981	2.75	122	293	4.4	4.58	10:14
Converter Stack	1982-1986	0.66	122	293	4.4	4.68	3:03
Reverb Stack	1948-1960	1.51	25	384	10	15.36	10:14
Dore Stack	1907-1981	0.27	11	355	1	5.59	10:14
Dore Stack	1982-1986	0.03	11	355	1	5.59	3:03
Arc Furnace	1972-1981	0.15	22	330	10	1.38	10:14
Arc Furnace	1982-1986	0.08	22	330	10	1.158	3:03

Cupola Fugitives:

Period	g/second	Reference
1907-1947	6.49	Ref 21:1
1948-1981	2.22	Dunk Ref 4:4
1982-1986	0.22	Ref 3:3

Converter Fugitives:

Period	g/second	Reference
1907-1947	9.72	Ref 21:1
1948-1981	1.8	Ref 5:3
1982-1986	0.34	Ref 3:3

Anode Tough Pitch Arc Furnace:

Period	g/second	Reference
1972-1983	0.08	18:5
1984-1986	0.02	3:3

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[6] Note that as of 1982-1986 the total emissions based on USMR (Ref 3:3) was 129 tons/ year of lead. This figure can be compared to 86 tons / year of lead shown in the 1984 State Implementation Plan for USMR, as documented by the New Jersey Department of Environmental Protection (Ref 49:28). (Ref 30:37) (Radian 1986 report) on the other hand shows total emissions of 29 tons / year, which appears to be more relevant to the emissions near the time of plant closure in the fall of 1986.

Note that (Ref 30:37) shows non-process fugitives as of the year 1986 to be 0.10 g/sec. These emissions were shown to be dominated by baghouse dust loading/unloading and wind-blown emissions. As noted in (Ref 30:40), these emissions are considered to be "*very uncertain*" and are relatively low compared to other emissions. Due to these factors, non-process emissions were not included in the modeling analysis. If included, the modeled impacts would be higher.

The modeling run described in this report as Scenario 2 was run for purposes including sensitivity testing. The assumptions in terms of the modeling inputs are the same as Scenario 1 except that:

(1) It is based on the assumption that the largely uncontrolled emissions assumed by Dr. McVehil from the years 1907 through 1947 extended through the year 1970 when the Clean Air Act came into effect, a regulatory framework that led to the need for tighter controls, which also helps to bracket the phase-in is of controls.

(2) This scenario also modifies an assumption of Dr. McVehil. Since he did not have access to the field research studies and data associated to these studies of Mr. Dunk, Dr. McVehil assumed a uniform 10 percent lead fraction in the stack and fugitive sources. Most notably, this assumption is inconsistent with the approximately 25 percent lead shown for the cupola field study (Ref 4:4). On that basis, Scenario 2 uses Dr. McVehil's emissions data for the cupola stack and fugitives but multiplied times the ratio of 25 to 10, i.e. a factor of 2.5-fold.

Refer to Table 4 for a summary of the emissions and stack specifications used for Scenario 2.

Table 4: Emission Rates and Assumed Stack Specifications for Scenario 2

Stacks:

	Time Step	g/sec	Height (m)	Temp (k)	m/sec	Dia (m)	Reference
Cupola Stack	1907-1970	481.2	60.96	425	8	4.5	21:01
Cupola Stack	1971-1981	3.67	76	402	20	3.54	10:14
Cupola Stack	1982-1986	0.81	76	400	20.1	3.54	3:03
Converter Stack	1907-1947	70.83	60.96	435	7	4	21:01 & 2:02
Converter Stack	1948-1970	70.83	122	293	4.4	4.58	10:14
Converter Stack	1971-1981	2.75	122	293	4.4	4.58	10:14
Converter Stack	1982-1986	0.66	122	293	4.4	4.68	3:03
Reverb Stack	1948-1960	1.51	25	384	10	15.36	10:14
Dore Stack	1907-1981	0.27	11	355	1	5.59	10:14
Dore Stack	1982-1986	0.03	11	355	1	5.59	3:03
Arc Furnace	1972-1981	0.15	22	330	10	1.38	10:14
Arc Furnace	1982-1986	0.08	22	330	10	1.158	3:03

Note: the stack specs for the converter 1948-1970 are the same as the last converter stack specs but the emission rate is different.

Cupola Fugitives:

Period	g/sec	Reference
1907-1970	16.22	Ref 21:1 * 2.5
1971-1981	2.2	Ref 4:4
1982-1986	0.22	Ref 3:3

Converter Fugitives:

Period	g/sec	Reference
1907-1970	9.72	Ref 21:1
1971-1981	1.8	Ref 5:3
1982-1986	0.34	Ref 3:3

Anode Tough Pitch Arc Furnace:

Period	g/sec	Reference
1972-1983	0.08	18:5
1984-1986	0.02	3:3

6.2 Meteorological Input Data

Figure 12 presents a wind rose based on Newark International Airport, New Jersey, which is representative of the area in which the USMR smelter was located.

6.3 Receptor Data

Figure 13 shows the general receptor grid used for the deposition modeling analysis. The deposition modeling grid incorporated more than 10,000 receptors in order to generate significant resolution in terms of deposition impacts.

Figure 12: Wind Rose Based on Newark Airport (years 2013-2017)

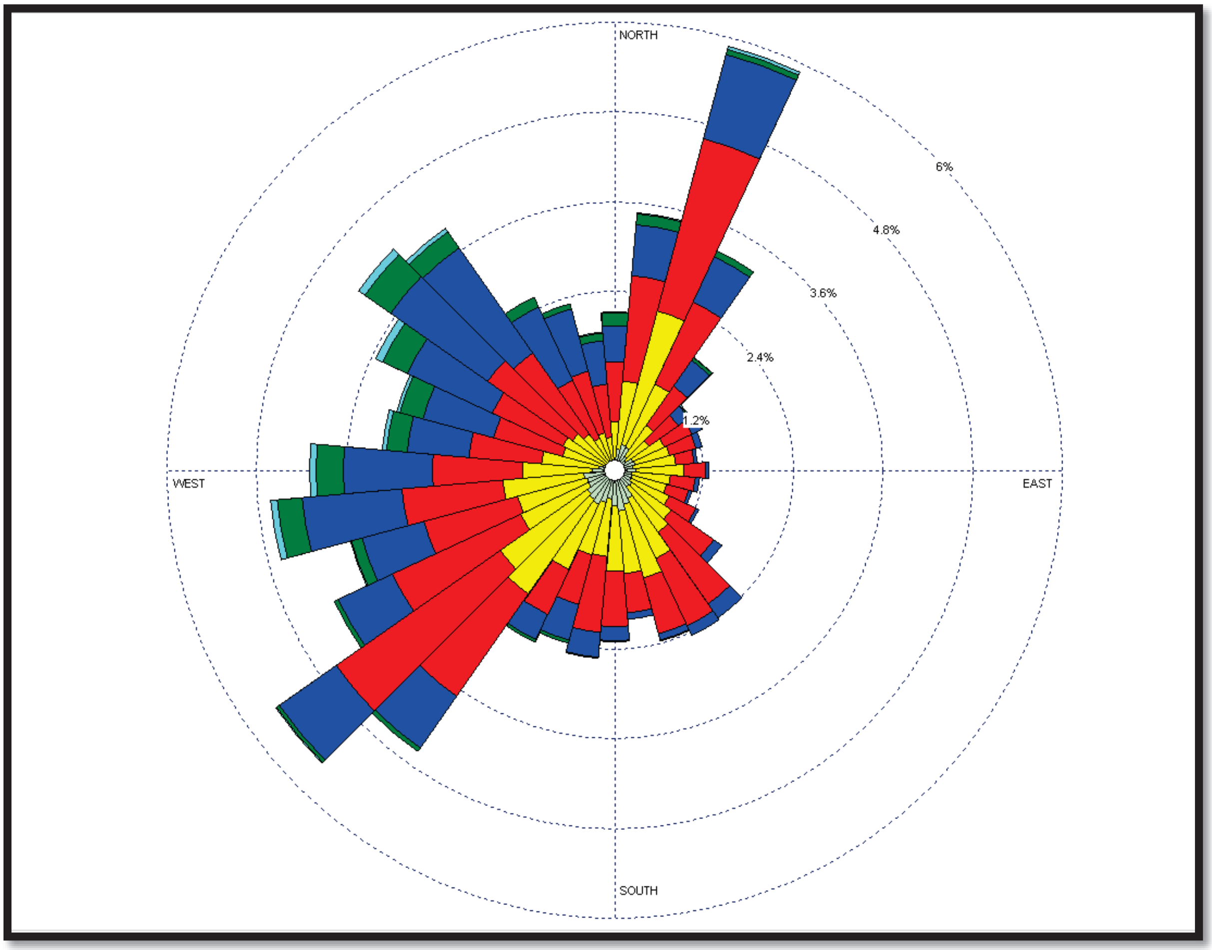

Figure 13: Primary Receptor Grid Used in the AERMOD Deposition Modeling

6.4 Model Set-Up

The modeling was conducted using reliable, peer-reviewed methods. The AERMOD dispersion model was run in the standard EPA regulatory mode which is consistent with the EPA Guideline on Air Quality Models. Options were selected to account for wet and dry depletion. The model was run using the urban option based on EPA guidance. As stated in EPA's AERMOD Implementation Guide (USEPA, 2015): "When modeling urban sources, the urban algorithms in AERMOD are designed to enhance the turbulence levels relative to the nearby rural setting during nighttime stable conditions to account for the urban heat island effect (Cimorelli, et al., 2004)."

In Section 5.2 of EPA's AERMOD Implementation Guide (USEPA, 2015)[7], there is guidance on how to select the appropriate population data for input to the AERMOD when modeling using the urban option. In particular, that guidance states: "For urban areas adjacent to or near other urban areas, or part of urban corridors, the user should attempt to identify that part of the urban area that will contribute to the urban heat island plume affecting the source(s)."

In this case it was determined that the population for the two adjoining counties in association with this facility, i.e., Middlesex and Union counties, would best define that urban population input parameter. Based on the latest available 2017 population data[8] the total population for these two counties is approximately 1.4 million people. This input parameter was used in terms of defining the population in terms of the modeling input.

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[7] Cimorelli, A. J., S. G. Perry, A. Venkatram, J. C. Weil, R. J. Paine, R. B. Wilson, R. F. Lee, W. D. Peters, R. W. Brode, and J. O. Paumier, 2004. AERMOD: Description of Model Formulation, EPA-454/R-03-004. U.S. Environmental Protection Agency, Research Triangle Park, NC.

USEPA, 2015: AERMOD Implementation Guide. U.S. Environmental Protection Agency, Office of Air Quality Planning Standards, Air Quality Assessment Division, Research Triangle Park, NC. August 3, 2015. [https://www3.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_3August2015.pdf]

[8] (https://en.wikipedia.org/wiki/Middlesex_County,_New_Jersey; https://en.wikipedia.org/wiki/Union_County,_New_Jersey).
Note that these references are further referenced to US census data.

6.5 Model Results

Section 6.5.1 describes the airborne lead concentration and lead deposition figures associated with emissions related to the operations of the USMR facility.

6.5.1 Airborne Concentrations

Figure 14 shows the concentration modeling results (of airborne lead concentrations) based on emissions and stack specifications applicable to the period when the USMR smelter operated from the years 1984 through 1986, i.e. during the last two years of operation based on Scenario 1 as an example. Table 5 presents comparative air quality modeling results for the Base Scenario and Scenario 1 for each time period. Results are shown for the applicable time step for runs applicable to the years: 1907-1947, 1948-1981, and 1982-1986 (the only period with measured airborne lead concentrations).[9] As shown, during the earlier years of operation, air quality concentrations were much higher than near the end of the operational life of the facility when environmental enforcement required effective improvements to emission controls. The Base Scenario is shown to overstate airborne impacts, while Run 1 is more in line with actual measured concentrations.

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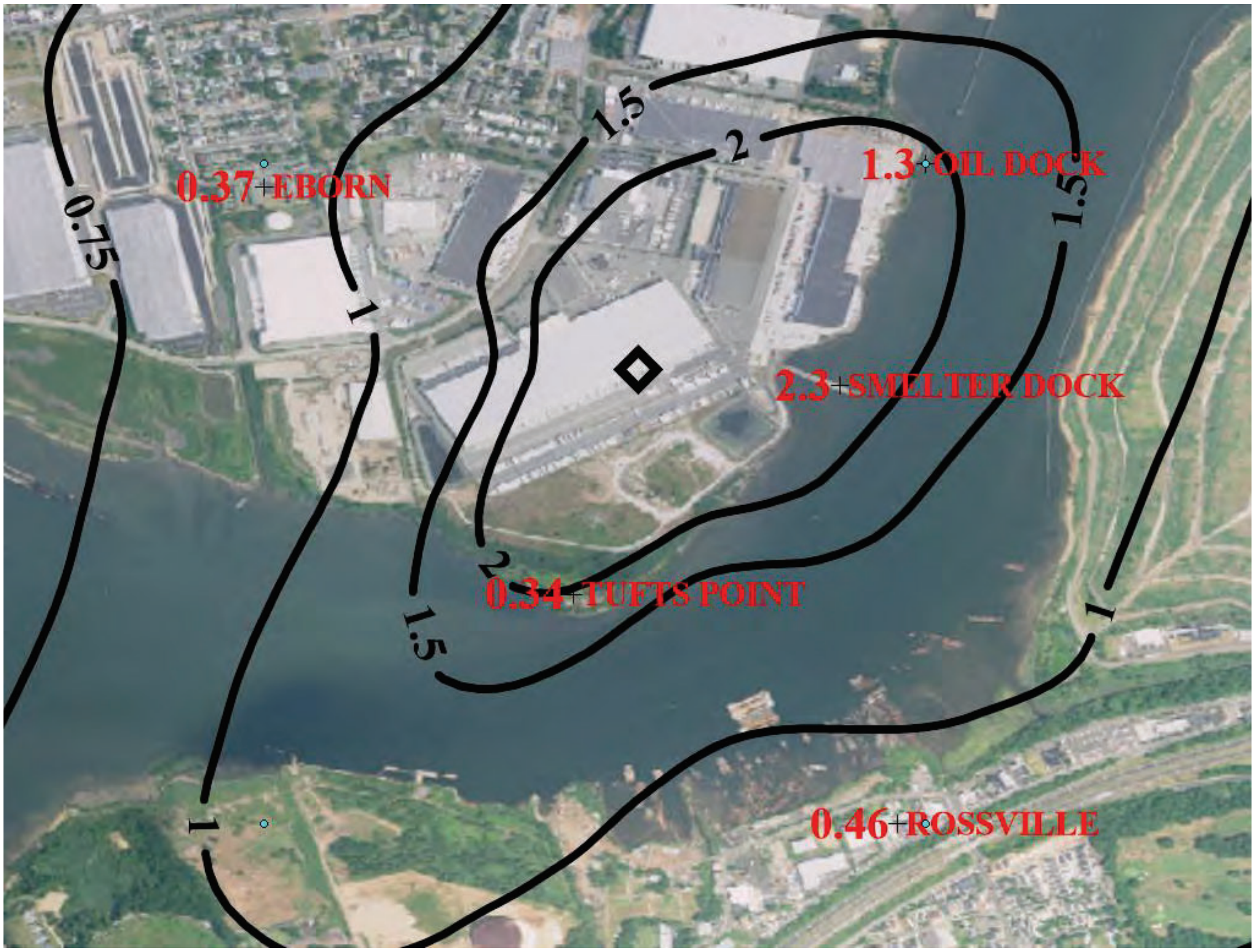
[9] For the period of 1982 through 1986 only the quarters associated with the monitoring period were used (i.e. nearly two years, from July 1, 1984 through March 31, 1986. The earlier two periods without available measured data are based on five-year averaging.

Figure 14: Modeled Airborne Lead Isopleth Analysis (µg/m^3) Overlaid with Available Measured Air Quality data for 1984-1986 Based on Run 2 as an Example [10]



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[10] Note that the Tufts Point and Eborn Pumping Station sites only operated during the 3rd and 4th quarters of the year 1986, when the smelter was no longer operational.

Table 5: Annual Average Airborne Concentration (μg/m^3) of Lead (including background 0.55 μg/m^3) as a Function of Modeling Scenario

Years	Site	Base Scenario	Scenario 1	Measured
1907-1947 (5-year meteorological data)	Smelter Dock	60.11	92.34	NA
	Oil Dock	51.87	67.80	NA
	Tufts Point	48.39	69.07	NA
	Eborn	23.16	20.61	NA
	Rossville	15.48	19.06	NA
1948-1981 (5-year meteorological data)	Smelter Dock	31.08	18.40	NA
	Oil Dock	28.08	13.00	NA
	Tufts Point	26.70	11.57	NA
	Eborn	12.43	3.58	NA
	Rossville	8.90	2.36	NA
1984-1986 (7/1/84-3/31/86	Smelter Dock	11.91	2.63	2.34
	Oil Dock	10.89	2.13	1.32
	Tufts Point*	10.15	1.94	0.34
	Eborn*	4.34	0.91	0.37
	Rossville	3.50	0.88	0.46

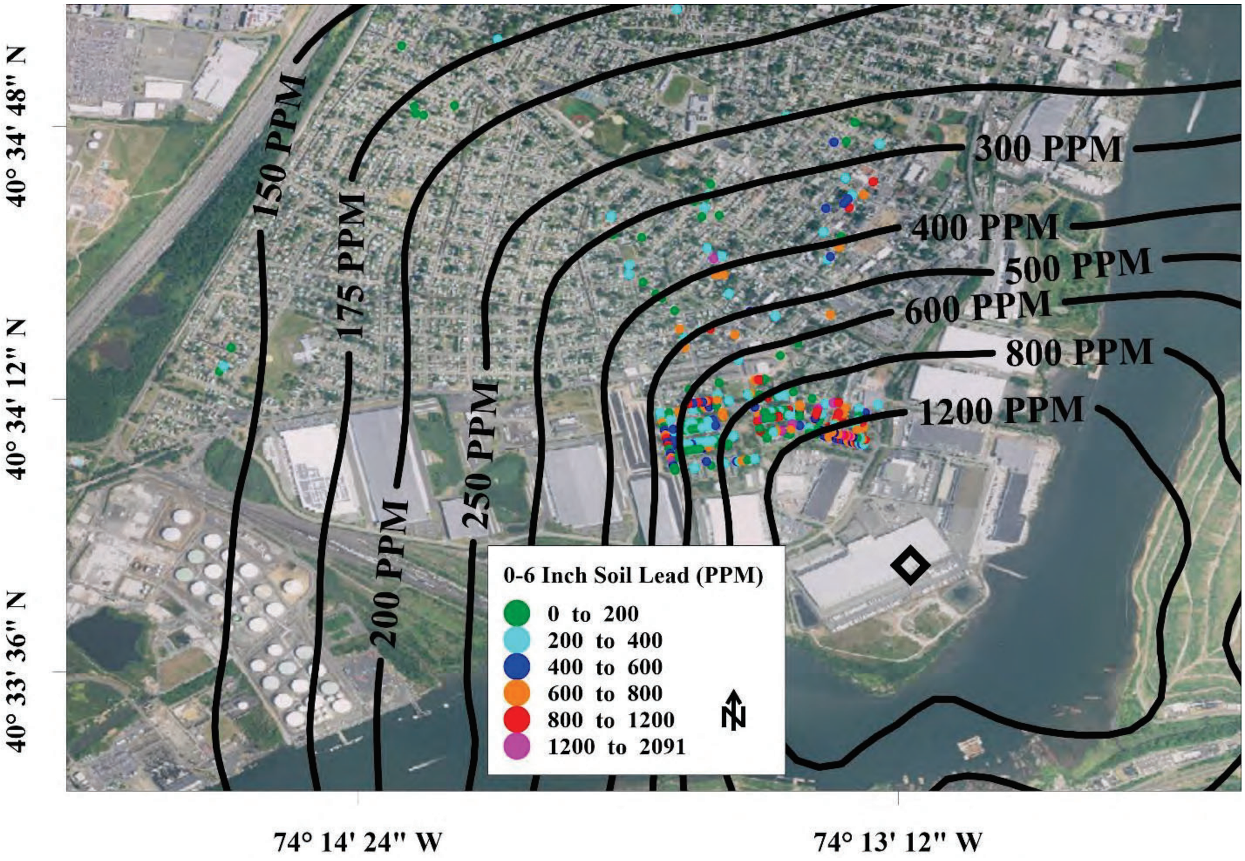
*Only operated the third and fourth quarters of 1986 when the smelter was no longer operational.

6.5.2 Deposition Analysis

Figures 15 through 17 show isopleths of the modeling of soil lead concentrations (ppm) from the years 1907 through 1986 based on emissions and stack specifications applicable to the Base Scenario, Scenario 1, and Scenario 2. The black triangle in these figures represents the approximate previous location of the U.S. Metal Refining Company Smelter. Deposition to the surface was summed for each of three periods and then incorporated into the soil based on the following assumptions:

- Soil bulk density = 1.34 g/cm^3 (Ref 53:1)
- 25 percent of lead is contained in the top 25 percent of the soil profile (See Section 5.3)
- Soil background for lead is assumed to be 62 ppm (Ref 34:41).

Figure 15: Modeled Soil Concentrations[11] of Lead Based on the Base Scenario for Years 1907-1986 Assuming the Inclusion of 62 ppm Background (overlaying measured soil data)



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[11] Including a lead background concentration of 62 ppm for Figures 15-17.

Figure 16: Modeled Soil Concentrations of Lead Based on Scenario 1 for Years 1907-1986 Including Assuming the Inclusion of 62 ppm Background (overlaying measured soil data)

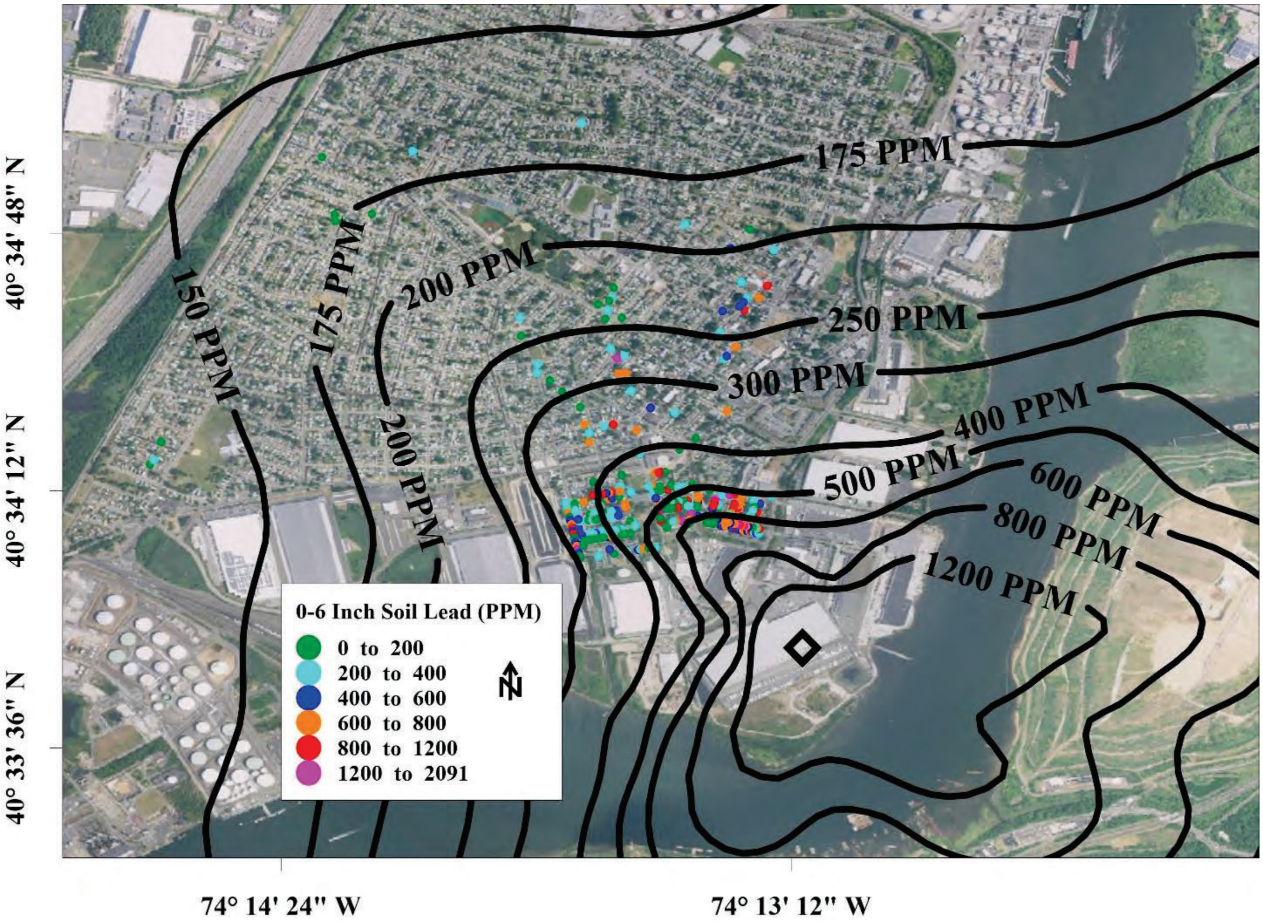
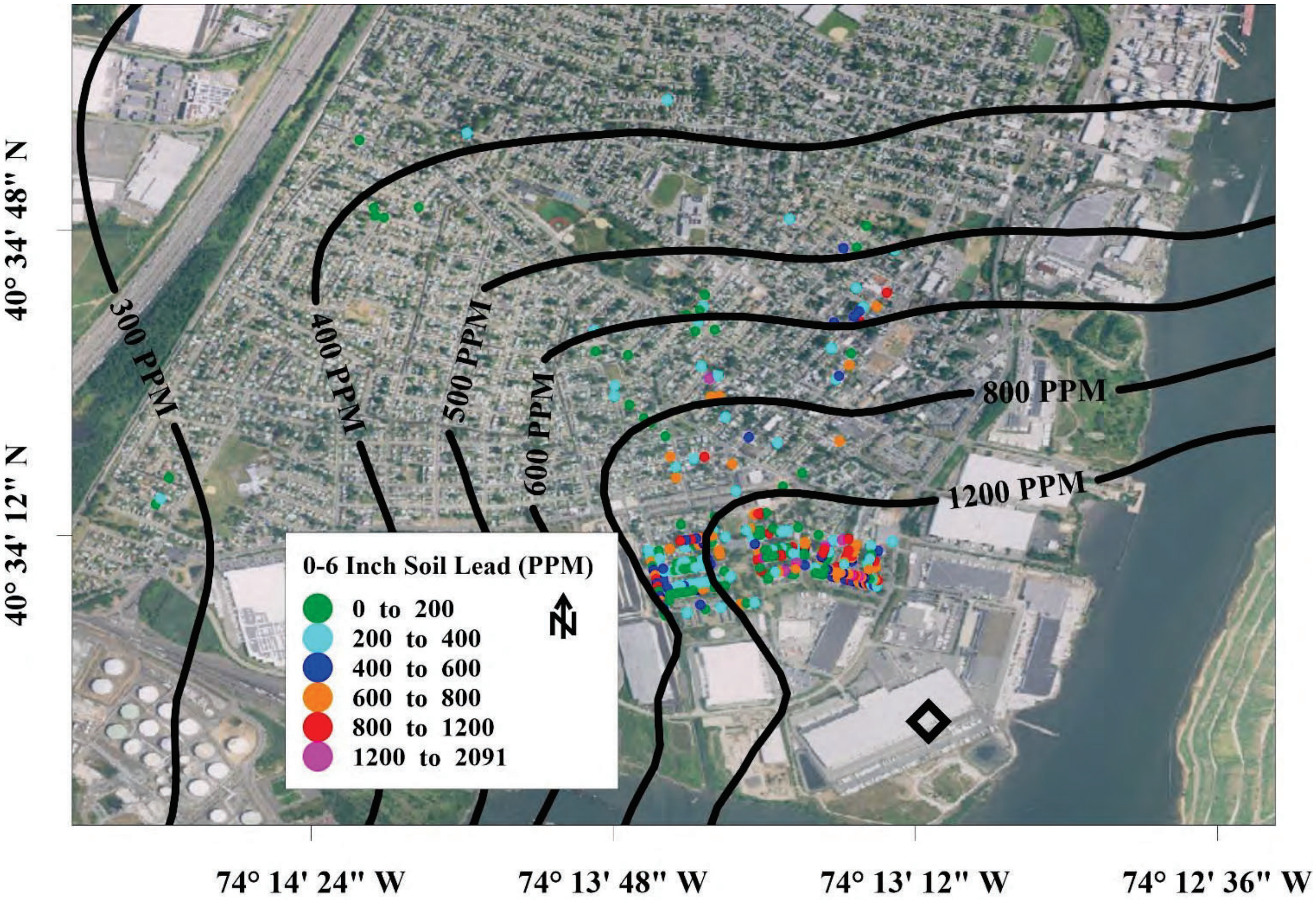


Figure 17: Modeled Soil Concentrations of Lead Based on Scenario 2 for Years 1907-1986 Including Assuming the Inclusion of 62 ppm Background (overlaying measured soil data)



6.6 Model Performance Evaluation: Soils Data

6.6.1 Soils Analysis

Refer to the plots in Section 6.5 that show isopleths of modeled soil contamination in the top 6 inches of the soil profile. It should be noted when interpreting the modeled soil contamination, the model is effectively estimating smoothed deposition rates, which show spatial trends decreasing with distance from the smelter operation. Some variation in soil concentrations would be expected based on preferential and non-preferential deposition zones caused by localized recirculation zones. Such variation is consistent with my opinion that all of the properties within the proposed class area were dusted for over approximately 80 years with airborne deposited lead, arsenic, and other particulate matter emitted by the USMR facility.

It also should be noted that the modeling of the USMR emissions data does not account for all of the deposited mass. If all sources could be specifically accounted for, including upset conditions and periods associated with the numerous violations of permits (Ref 30:20-21), the modeled estimates would obviously be higher. Mr. Dunk assumes that all the fugitive emissions from the cupola and converter were released from the exhaust points where the monitors were located. Other losses are expected but could not be quantified. Similarly, Dr. McVehil's estimates of the early fugitive emissions may be understating actual emissions. What is observed, however, is that the general pattern and decrease of modeled soil concentration with distance from USMR are reasonably consistent with the measured soil contamination data. The observed soil contamination in Carteret, NJ was dominated by airborne deposition impacts of heavy metals from the USMR operations throughout and beyond the proposed class area (Ref 58:1).

7.0 OTHER SOURCES

7.1 Industrial Sources

The USMR facility was located in an industrialized area of New Jersey. Figures 18 and 19 show examples of industrial facilities that were located in the general vicinity of the USMR smelting operations. Although there are many sources in the vicinity of the USMR smelter, USMR is the only facility that met the following two criteria: (1) large enough lead source to create lead impacts of this magnitude, and (2) geographically located consistent with the observed decrease of metals concentrations with distance from the source.

(Ref 49:28) presents lead emissions data for New Jersey based on the New Jersey Department of Environmental Protection’s State Implementation Plan (SIP) for 1984. Table 6 presents the New Jersey DEP lead emissions summary for the base year 1982. As shown, there are no other large industrial sources of lead in the vicinity of Carteret, NJ besides the USMR facility. The magnitude and pattern of soil contamination is consistent with the emissions from the USMR facility.

Table 6: Industrial Emissions of Airborne Lead in 1982 According to the New Jersey Department of Environmental Protection's Lead State Implementation Plan Drafted in January 1984 (Ref 49:28)

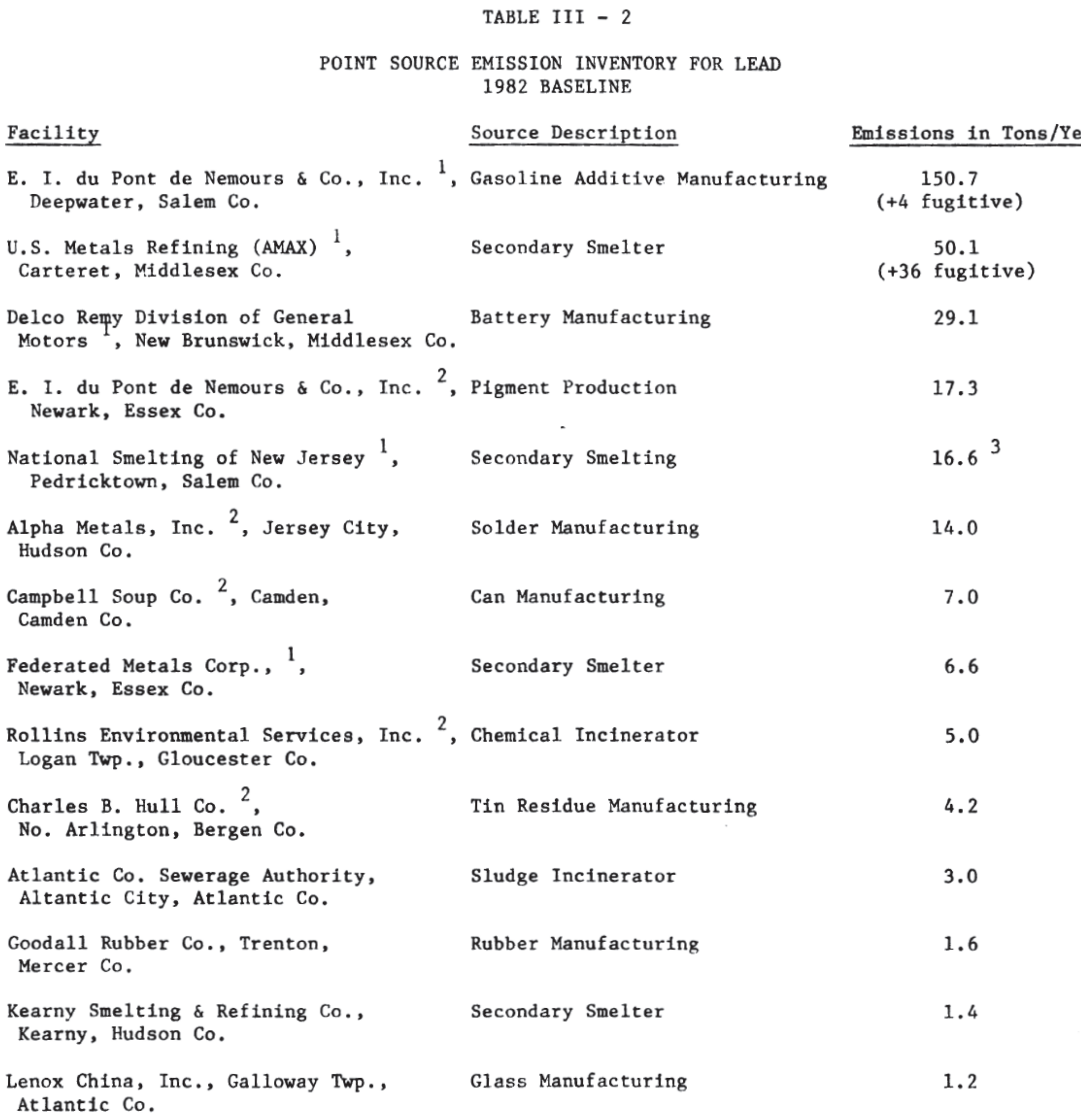


TABLE III - 2

POINT SOURCE EMISSION INVENTORY FOR LEAD
1982 BASELINE

Facility	Source Description	Emissions in Tons/Ye
E. I. du Pont de Nemours & Co., Inc. [1], Deepwater, Salem Co.	Gasoline Additive Manufacturing	150.7 (+4 fugitive)
U.S. Metals Refining (AMAX) [1], Carteret, Middlesex Co.	Secondary Smelter	50.1 (+36 fugitive)
Delco Remy Division of General Motors [1], New Brunswick, Middlesex Co.	Battery Manufacturing	29.1
E. I. du Pont de Nemours & Co., Inc. [2], Newark, Essex Co.	Pigment Production	17.3
National Smelting of New Jersey [1], Pedricktown, Salem Co.	Secondary Smelting	16.6 [3]
Alpha Metals, Inc. [2], Jersey City, Hudson Co.	Solder Manufacturing	14.0
Campbell Soup Co. [2], Camden, Camden Co.	Can Manufacturing	7.0
Federated Metals Corp., [1], Newark, Essex Co.	Secondary Smelter	6.6
Rollins Environmental Services, Inc. [2], Logan Twp., Gloucester Co.	Chemical Incinerator	5.0
Charles B. Hull Co. [2], No. Arlington, Bergen Co.	Tin Residue Manufacturing	4.2
Atlantic Co. Sewerage Authority, Altantic City, Atlantic Co.	Sludge Incinerator	3.0
Goodall Rubber Co., Trenton, Mercer Co.	Rubber Manufacturing	1.6
Kearny Smelting & Refining Co., Kearny, Hudson Co.	Secondary Smelter	1.4
Lenox China, Inc., Galloway Twp., Atlantic Co.	Glass Manufacturing	1.2

Figure 18: Examples of Other Sources in the Vicinity of the USMR Facility

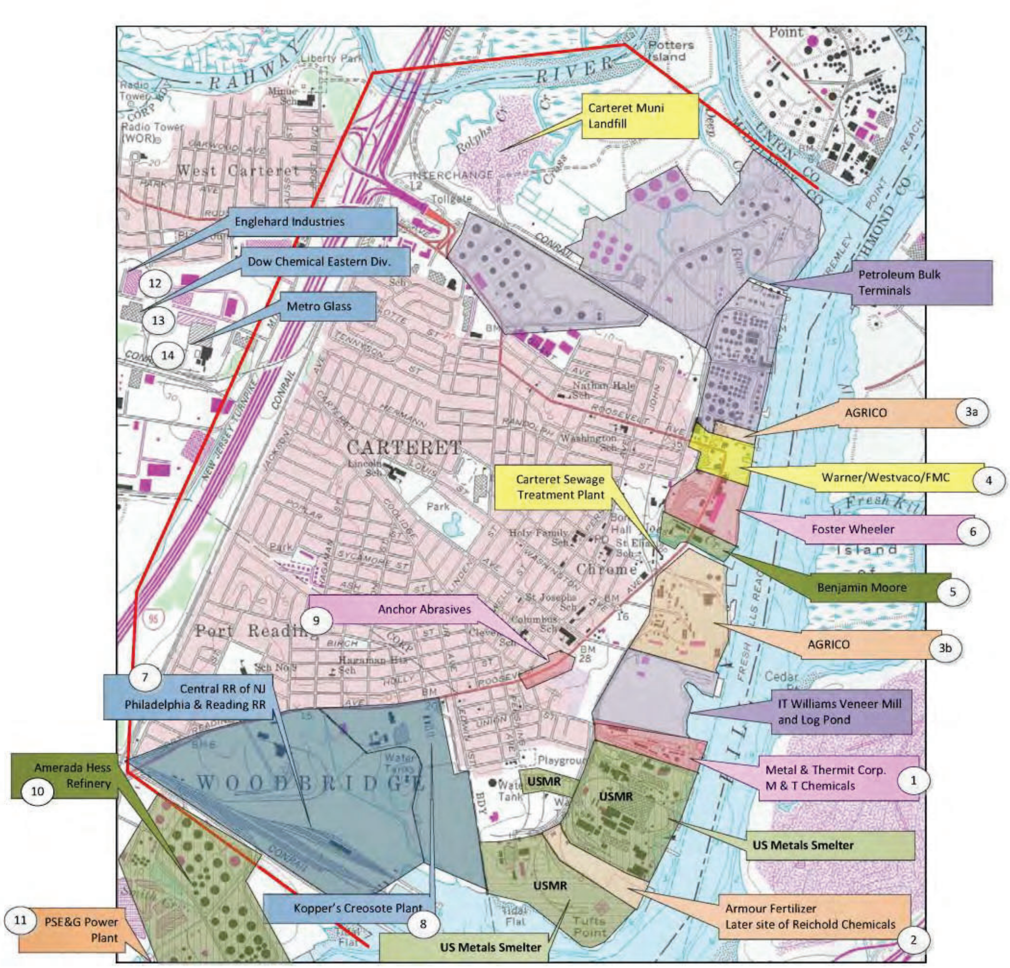
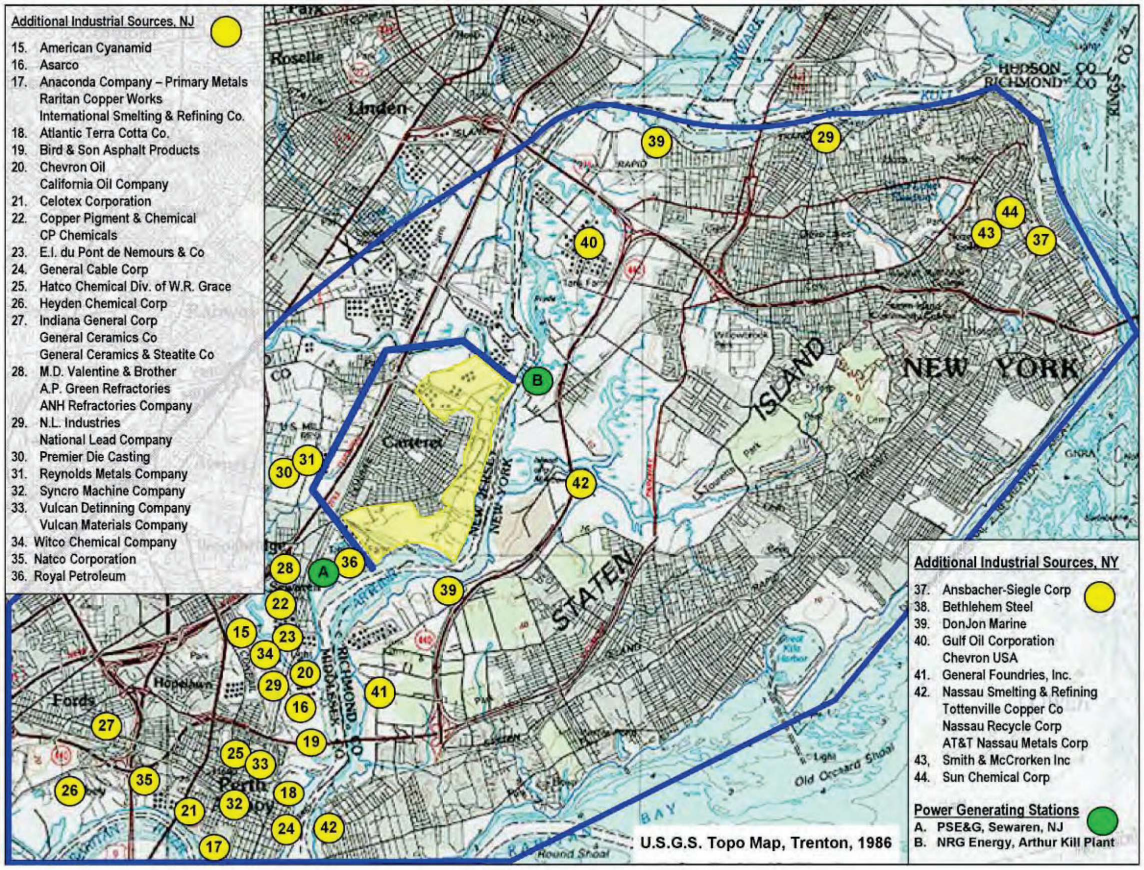


Figure 19: Broader View of Other Industries (Staten Island, NY)



7.2 Agricultural Sources

Lead arsenate was used as a pesticide from approximately 1917 to 1967 in New Jersey (Ref 50:10). Most of the use was for apple orchards, with lesser uses for vegetable crops and other fruit orchards. The typical application rate was several pounds per acre (Ref 50:11). Non-agricultural soils in New Jersey were found to have average concentrations of 3 ppm for arsenic and 19 ppm for lead (Ref 50:21). The Cranbury site in (Ref 50:15) is the only data available in this reference for agricultural soil in Middlesex County, New Jersey. This site had a reported median of 16 ppm for arsenic (lead data was not available). Across the full data set in (Ref 50:15), the median concentration for agricultural soils across the sites in New Jersey was 19 ppm for arsenic and 52 ppm for lead. The soil contamination levels in agricultural soils is much lower than the heavily impacted area in residential areas in Carteret. Simply based on the application rates and receiving volume of soil there is not enough mass to produce the high levels of soil contamination found in the residential areas near the smelter. Most of the relatively high arsenic and lead concentration in the agricultural soils as shown in (Ref 50:15) is for the orchards. Based on aerial photography, I have not seen evidence of orchards in the housing stock west of Carteret, NJ where the highest impacts from the smelter operations occurred. In addition, by 1940, the residential area to the west of the USMR facility that is most impacted by the smelter was residential (Ref 51:68), which would limit the potential for agricultural-related impacts. Agricultural sources do not explain the pattern or magnitude of the observed soil contamination.

7.3 Slag

Refer to (Ref 51:48), which shows an example of where slag, ash, and cinders were used for road maintenance. There were multiple materials used for this purpose and slag from various sources, which complicates an in-depth analysis of the contribution from this source category. A broader review of this source category is more practical. While it would be expected that there would be some heavy metals in these materials, the general decreasing pattern of heavy metals from the smelter is not consistent with the distribution of roadway use as shown in (Ref 51:48). If slag use for roadway maintenance were a dominant source, there would be a more uniform pattern of soil contamination centered on the roadway areas where it was used. While it would be expected that the impacts would be relatively high adjacent to roadways compared to the rest of the affected properties, a general decreasing trend from the smelter would not be expected. As the measured data show, however, a general decreasing trend from the smelter is what has occurred. The observation is inconsistent with the hypothesis that slag is an important contributor to the observed heavy metal contamination. The use of slag for road maintenance does not explain the pattern or magnitude of the observed soil contamination.

7.4 Leaded Paint

The use of exterior leaded paint can cause relatively high concentrations of lead in the dripline of a roof if the following two conditions are met: (1) leaded paint was used, and (2) the paint has peeled or has been scraped. The drip line also is complicated because it also drains the airborne deposited lead associated with the airborne deposition pathway. Review of the measured soil data, however, reveals general heavy metal contamination throughout many yards for lead and arsenic, i.e. not just contamination in the dripline areas. Furthermore, there is not sufficient lead in coatings of paint to produce hundreds of ppm of lead of the receiving soils throughout individual properties. In summary, leaded paint does not explain the observed magnitude and pattern of soil contamination that is shown by the measured soil data.

8.0 STATISTICAL ANALYSIS ASSOCIATED WITH REMEDIATION

The U.S. Environmental Protection Agency (EPA) has established guidance documents and software to support the evaluation of the 95 percent upper bound confidence limit of the mean (UCL) of soil concentration (References 44 and 45). This statistic is important for the determination of whether or not functional areas within properties will be remediated. As part of these guidance documents, EPA provides clear instructions regarding how to treat potential outliers, i.e. upper-bound soil concentrations within soil data sets collected at functional areas within specific properties. New Jersey recommends (Ref 42:33) that the EPA software package ProUCL (Ref 44) be used to evaluate the UCL, which aligns New Jersey guidance with EPA guidance.

The following quote from EPA summarizes how authoritative sources such as EPA (and the New Jersey Department of Environmental Protection by reference) recommend outliers be addressed (Ref 45:6-7):

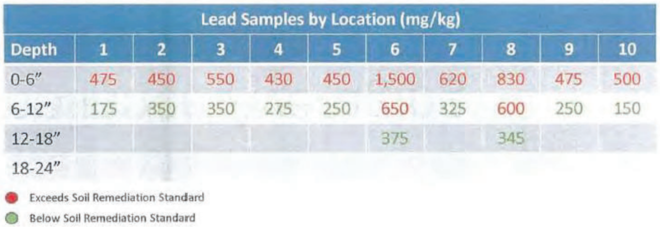
"*Outliers are values in a data set that are not representative of the set as a whole, usually because they are very large relative to the rest of the data. There are a variety of statistical tests for determining whether one or more observations are outliers (EPA 2000b, section 4.4). These tests should be used judiciously, however. It is common that the distribution of concentration data at a site is strongly skewed so that it contains a few very high values corresponding to local hot spots of contamination. The receptor could be exposed to these hot spots, and to estimate the EPC* (exposure point concentration) *correctly it is important to take account of these values. Therefore, one should be careful not to exclude values merely because they are large relative to the rest of the data set. Extreme values in the data set may represent true spatial variation in concentrations. If an observation or group of observations is suspected to be part of a different contamination source or exposure unit, then regrouping of the data may be most appropriate. In this case, it may be necessary to evaluate these data as a separate hot spot or to resample. The behavior of the receptor and the size and location of the exposure unit will determine which sample locations to include. Such decisions depend on project-specific assessments based on the conceptual site model. EPA guidance suggests that, when outliers are suspected of being unreliable and statistical tests show them to be unrepresentative of the underlying data set, any subsequent statistical analyses should be conducted both with and without the outlier(s) (EPA 2000b). In addition, the entire* *process, including identification, statistical testing and review of outliers, should be fully documented in the risk characterization."* (Ref 45:6-7).

This is not, however, what was done by USMR. Rather, USMR concluded that many highly skewed data sets for functional areas at individual properties had outliers at the upper tail of the distribution and eliminated these samples prior to computing compliance averages. There are two appropriate reasons to disregard a high value:

(1) **Invalid Samples** – Instrument failure, calibration errors, transcription errors, etc. can result in invalid samples. Follow-up review could have identified if such reasons caused the potential outlier samples and the results could have been corrected or appropriately eliminated from compliance averaging. I did not see any field notes or laboratory records or comment lines in the data base that indicated based on follow-up investigation that samples were considered outliers because they were invalid (such as due to field contamination or erroneous laboratory analysis). Rather the decision on outliers was based on statistical review through the EPA ProUCL software (Ref 47:43).

(2) **Samples were From a Different Population** – In this matter, this would involve a sample dominated by a different pathway than air deposition. The key question: are the high values from the same population (i.e. are they likely from airborne deposition pathway) or rather are the outliers from other pathways such as buried lead waste, paint chips, etc.) Absent investigation to support the position that the sample represented a different population (such as buried waste or leaded paint drip line), it should have been assumed that the sample was from the air deposition pathway and was located in an area of the property that was in a preferential deposition zone.

Arcadis deposition testimony (Ref 47:43) indicates that the decision on outliers was statistically based on ProUCL, an EPA statistical software package, for each individual depth (Ref 47:43). The examples provided in (Ref 55:2 and Ref 55:4), however, regarding compliance averaging can be matched by compositing all three depths (i.e. all samples all depths) to match the 575 ppm UCL (using approximate Gamma distribution basis) for Example 1 and the 580 ppm UCL (using adjusted Gamma distribution basis) for Example 2. In this example as shown in (Ref 55), there is a sample at location #6 that is 1,500 ppm among the following 10 samples:



Lead Samples by Location (mg/kg)										
Depth	1	2	3	4	5	6	7	8	9	10
0-6"	475	450	550	430	450	1,500	620	830	475	500
6-12"	175	350	350	275	250	650	325	600	250	150
12-18"						375		345		
18-24"										

🟥 Exceeds Soil Remediation Standard
🟩 Below Soil Remediation Standard

The Dixon outlier test in ProUCL for this full data set of 15 samples shows the 1,500 ppm as a statistical outlier assuming a Gamma distribution fit. Is the 1,500 ppm concentration: (a) an invalid sample, (b) from a different population (i.e. not related to airborne deposition), or (c) is it simply a high sample associated with airborne deposition but at a location with preferential deposition? Statistics do not answer this question. Follow-up analysis could potentially provide a definitive answer, but the available record particularly based on (Ref 47:43) is that statistical outliers were implicitly assumed by USMR to be Option "a" or Option "b" above and excluded from the calculation of the compliance averaging on statistical grounds. There is no justification for this approach in either the New Jersey or EPA guidance (References 42, 44, or 45).

There was no documentation in the information I reviewed that provided any evidence of further investigation whether or not the highly skewed samples were associated with the air pathway. Simply, if the statistical tests suggested this was an outlier, the sample was not considered further in compliance averaging, i.e. "*statistical remediation*" was effectively performed. This is in conflict with EPA guidance as stated above, as well as ProUCL guidance: "*The philosophy (with input from EPA scientists) of the developers of ProUCL about the outliers in environmental applications is that those outliers (unless they represent typographical errors) may potentially represent impacted (site related or otherwise) locations or monitoring wells; and therefore may require further investigation.* (Ref 44:69)."

Statistical remediation on this case can be summarized as follows. First, evaluate only on a statistical basis potential outliers one depth at a time and then remove in some functional areas the highest samples as "*outliers*" without further investigation or justification. Then compute compliance averaging across multiple depths, thereby statistically diluting the remaining higher concentration samples with potentially lower concentrations from other depths and areas. Produce on this basis a "compliance average" (which is different than the actual averages on a layer-by-layer basis) that can leave in place highly contaminated areas. When presenting the results to home owners, however, only present the compliance average results*: "On PPIN 1026, method indicates that no remediation is required even though we have a Pb exceedance at 6-12". However, since we're reporting the individual UCLs to residents, we'll need to carefully review how we provide the numbers to the property owners. (Ref 57:1)."* This approach avoids showing home owners highly contaminated areas within their property that will remain in place. The process obviously is not transparent to the home owners.

There is an important distinction between the air deposition pathway and other pathways for environmental contamination that are addressed by the ProUCL software. I have evaluated airborne deposition from four lead smelters, two Superfund mining waste matters, the areal deposition of pesticides, wood dust, ash, and salt drift. Data sets consistently show general trends from major sources but with scatter in the data. Yard-to-yard differences may exist. Soil contamination within a property may show differences in concentrations in some quadrants that are much higher than others. This is the norm, not the exception. A Gamma distribution may be the best approximation available in ProUCL for most of the sample sets, for example, but assuming areas that are 2-3 times higher than typical areas within a property is inconsistent with the nature of airborne deposition data sets whether or not an outlier statistical test indicates a potential outlier. Removing high values as "*outliers*" potentially removes areas from remediation that are the most contaminated.

There is an important physical reason for these observations. Within a property, there are numerous obstacles to wind flow; including homes, sheds, garages, trees, shrubs, sandboxes, etc. Such obstacles create complex recirculation flow zones (small and larger) that result in preferential areas for deposition and zones where less deposition can occur. If one were to take 10 randomly selected borehole samples within a yard, one would expect to see highly skewed results in one or two areas. Sound science as well as sound statistical analysis require that all samples should be considered in the data set unless a sound basis exists for its inclusion.

Based on the above, it is my opinion that there are areas within properties that should have been remediated but based on the decision processes in place by Arcadis and accepted by USMR, they were not listed for remediation, and these high "*outlier*" concentration areas are still in place. Best science would dictate that USMR's actions in terms of "*outlier*" removal should be objectively reassessed and the basis for the no remediation decisions of portions of functional areas should be reassessed based on sound scientific grounds. As EPA also has stated: "*It should be noted that in environmental applications, one of the objectives is to identify high outlying observations that might be present in the right tail of a data distribution, as those observations often represent contaminated locations requiring further investigations*" (Ref 44:116). Rather than investigate, the highly skewed data points were just removed prior to compliance averaging.

USMR made decisions on outliers based on assumed distributions including the use of Gamma and Chebyshev distributions. As stated by EPA in (Ref 45:15), however: "*for highly skewed lognormal data with small sample size and large standard deviation, the Chebyshev 99% UCL may be more appropriate than the 95% UCL, because the Chebyshev 95% UCL may not provide adequate coverage of the mean. As skewness increases further, the Chebyshev method is not recommended.*" As documented in USMR document (Ref 54:19), however, USMR specifically chose to use the 95 percent upper confidence limit rather than the ProUCL recommendation of 99th percent upper confidence limit when using Chebyshev distributions as the basis for compliance averaging.

Figures 20 through 27 and Tables 7 through 14 present examples of properties where outliers were removed from the data set and the approximate sampling locations in the yard based on the TIA database. Samples that were removed are highlighted in yellow.

Figure 20: Soil Lead Concentration Plot for 12-18" depth for PPIN # 1041-F02

Table 7: Soil Concentration Table for 12-18" depth for PPIN # 1041-F02

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
1041	1041-F02-01-CG-G0095	12 - 18	11.2	132	170
1041	1041-F02-02-CG-G0100	12 - 18	8.70	62.6	850X
1041	1041-F02-02-CG-G0101	12 - 18	8.70	62.2	998X
1041	1041-F02-03-CG-G0105	12 - 18	12.7	95.6	299
1041	1041-F02-04-CG-G0110	12 - 18	15.2	115	282
1041	1041-F02-05-CG-G0114	12 - 18	10.4	85.3	192
1041	1041-F02-06-CG-G0118	12 - 18	19.9	137	309
1041	1041-F02-07-CG-G0122	12 - 18	9.90	120	147
1041	1041-F02-08-CG-G0127	12 - 18	7.00	24.1	37.7
1041	1041-F02-09-CG-G0131	12 - 18	7.70	94.4	188
1041	1041-F02-10-CG-G0136	12 - 18	8.80	40.3	121

Figure 21: Soil Lead Concentration Plot for 6-12” depth for PPIN #3048-F01

Table 8: Soil Concentration Table 6-12” depth for PPIN #3048-F01

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
3048	3048-F01-01-BG-G0002	6 - 12	10.7	84.5	120
3048	3048-F01-02-BG-G0006	6 - 12	5.30	68.1	64.9
3048	3048-F01-03-BG-G0010	6 - 12	12.7	127	233
3048	3048-F01-03-BG-G0011	6 - 12	27.5	321	577
3048	3048-F01-04-BG-G0015	6 - 12	12.5	127	185
3048	3048-F01-05-BG-G0019	6 - 12	18.2	213	307
3048	3048-F01-06-BG-G0023	6 - 12	10.4	121	153
3048	3048-F01-07-BG-G0029	6 - 12	42.0X	332X	674X
3048	3048-F01-08-BG-G0033	6 - 12	9.70	94.2	161
3048	3048-F01-09-BG-G0040	6 - 12	9.10	92.7	141
3048	3048-F01-10-BG-G0044	6 - 12	12.6	154	264

Figure 22: Soil Lead Concentration Plot for 12-18" depth for PPIN # 3065-F01

Table 9: Soil Concentration Table for 12-18" depth for PPIN # 3065-F01

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
3065	3065-F01-01-CG-G0003	12 - 18	1.30	13.0	13.6
3065	3065-F01-02-CG-G0010	12 - 18	2.30	17.3	30.3
3065	3065-F01-03-CG-G0017	12 - 18	1.10	9.80	13.6
3065	3065-F01-04-CG-G0022	12 - 18	6.30	70.4	78.7
3065	3065-F01-05-CG-G0027	12 - 18	6.20	65.6	96.3
3065	3065-F01-06-CG-G0031	12 - 18	5.40	12.5	13.1
3065	3065-F01-07-CG-G0035	12 - 18	14.7	146	212
3065	3065-F01-08-CG-G0039	12 - 18	14.5	150	218
3065	3065-F01-09-CG-G0043	12 - 18	14.6	137	205
3065	3065-F01-10-CG-G0047	12 - 18	27.0X	464X	577X
3065	3065-F01-01-CG-G0003	12 - 18	1.30	13.0	13.6

Figure 23: Soil Lead Concentration Plot for 0-6” depth for PPIN # 5287-B01

Table 10: Soil Concentration Table for 0-6" depth for PPIN # 5287-B01

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
5287	5287-B01-01-AG-G0001	0 - 6	25.5	298	982
5287	5287-B01-02-AG-G0011	0 - 6	30.0	459	1260
5287	5287-B01-03-AG-G0021	0 - 6	26.2	383	1400
5287	5287-B01-04-AG-G0033	0 - 6	21.8	285	726
5287	5287-B01-05-AG-G0042	0 - 6	47.0	517	3340X
5287	5287-B01-06-AG-G0052	0 - 6	23.3	382	932
5287	5287-B01-07-AG-G0061	0 - 6	17.4	208	550
5287	5287-B01-08-AG-G0070	0 - 6	26.1	402	1480
5287	5287-B01-09-AG-G0078	0 - 6	24.4	360	1060
5287	5287-B01-10-AG-G0088	0 - 6	12.4	124	252
5287	5287-B01-01-AG-G0001	0 - 6	25.5	298	982

Figure 24: Soil Lead Concentration Plot for 0-6” depth for PPIN # 4077-B03

Table 11: Soil Concentration Table for 0-6" depth for PPIN # 4077-B03

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
4077	4077-B03-01-AG-G0097	0 - 6	99.1X	2710X	1950X
4077	4077-B03-02-AG-G0107	0 - 6	4.10	108	41.5
4077	4077-B03-03-AG-G0115	0 - 6	6.00	250	124
4077	4077-B03-04-AG-G0124	0 - 6	4.70	189	83.4
4077	4077-B03-04-AG-G0125	0 - 6	2.80	106	37.9
4077	4077-B03-05-AG-G0133	0 - 6	4.60	213	68.7
4077	4077-B03-06-AG-G0141	0 - 6	5.70	96.6	66.1
4077	4077-B03-07-AG-G0149	0 - 6	3.60	151	55.6
4077	4077-B03-08-AG-G0160	0 - 6	14.2	193	120
4077	4077-B03-09-AG-G0168	0 - 6	6.70	160	66.1
4077	4077-B03-10-AG-G0178	0 - 6	8.80	343	123

Figure 25: Soil Lead Concentration Plot for 0-6" depth for PPIN # 6408-B01

Table 12: Soil Concentration Table for 0-6” depth for PPIN # 6408-B01

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
6408	6408-B01-01-AG-G0001	0 - 6	26.4	342	1080
6408	6408-B01-02-AG-G0012	0 - 6	27.1	455	768
6408	6408-B01-03-AG-G0024	0 - 6	25.6	414	721
6408	6408-B01-04-AG-G0034	0 - 6	26.0	359	761
6408	6408-B01-05-AG-G0042	0 - 6	48.3	817	1140
6408	6408-B01-06-AG-G0050	0 - 6	21.6	305	587
6408	6408-B01-07-AG-G0059	0 - 6	34.5	637	775
6408	6408-B01-08-AG-G0068	0 - 6	28.8	612	1320
6408	6408-B01-09-AG-G0078	0 - 6	15.8	305	465
6408	6408-B01-10-AG-G0087	0 - 6	33.8	836	2400X
6408	6408-B01-10-AG-G0088	0 - 6	28.6	549	970X

Figure 26: Soil Lead Concentration Plot for 0-6" depth for PPIN # 3095 B01

Table 13: Soil Concentration Table for 0-6” depth for PPIN # 3095 B01

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
3095	3095-B01-01-AG-G0001	0 - 6	16.1	230	436
3095	3095-B01-02-AG-G0006	0 - 6	16.6	327	489
3095	3095-B01-03-AG-G0010	0 - 6	42.6	937	1090X
3095	3095-B01-04-AG-G0015	0 - 6	32.3	509	699
3095	3095-B01-04-AG-G0016	0 - 6	33.3	546	744
3095	3095-B01-05-AG-G0020	0 - 6	25.7	514	708
3095	3095-B01-06-AG-G0024	0 - 6	17.5	284	386
3095	3095-B01-07-AG-G0028	0 - 6	16.8	284	559
3095	3095-B01-08-AG-G0032	0 - 6	15.8	243	447
3095	3095-B01-09-AG-G0037	0 - 6	16.9	1710X	475
3095	3095-B01-10-AG-G0041	0 - 6	16.1	230	436

Figure 27: Soil Lead Concentration Plot for 0-6” depth for PPIN # 4112 B01

Table 14: Soil Concentration Table for 0-6" for PPIN # 4112 B01

PPIN	Sample ID	Depth	Arsenic	Copper	Lead
4112	4112-B01-01-BG-G0002	0 - 6	12.4	54.4	71.2
4112	4112-B01-02-BG-G0013	0 - 6	25.6X	198	251
4112	4112-B01-03-BG-G0022	0 - 6	6.70	121	135
4112	4112-B01-04-BG-G0032	0 - 6	9.60	621X	749X
4112	4112-B01-04-BG-G0033	0 - 6	9.20	978X	1490X
4112	4112-B01-05-BG-G0041	0 - 6	17.7	203	298
4112	4112-B01-06-BG-G0049	0 - 6	11.3	88.0	232
4112	4112-B01-07-BG-G0057	0 - 6	9.10	95.2	362
4112	4112-B01-08-BG-G0066	0 - 6	9.90	92.8	173
4112	4112-B01-09-BG-G0075	0 - 6	10.2	106	319
4112	4112-B01-10-BG-G0083	0 - 6	12.4	166	293

Appendix A: Resume of David A. Sullivan, Certified Consulting Meteorologist (#256)

(*available on disk*)

Appendix B: Sequential Reference Files (*available on disk*)

Appendix C: Model Input / Output Files Needed to Replicate Modeling Analysis

(Available on disk)

UNITED STATES DISTRICT COURT
DISTRICT OF NEW JERSEY

JUAN DUARTE and BETSY DUARTE, on Behalf of Themselves and all Others Similarly Situated,	)	**Civ. No. 2:17-cv-01624-EP-MAH**
Plaintiffs,	)	
vs.	)	**ORDER GRANTING CLASS COUNSEL'S MOTION SEEKING AN AWARD OF REASONABLE COSTS, ATTORNEY FEES, AND INCENTIVE AWARDS**
UNITED STATES METALS REFINING COMPANY, *et al.*,	)	
Defendants.	)	

IT IS HEREBY ORDERED that Class Counsel's Motion Seeking an Award of Reasonable Costs, Attorneys' Fees, and Incentive Awards GRANTED. Accordingly, JND Class Action and Claims Solutions, Inc. ("JND"), is directed to:

1. issue a check to the law firm of German Rubenstein LLP in the amount of $19,900,000 for attorneys' fees;

2. issue a check to the law firm of German Rubenstein LLP in the amount of $992,396.59 for reimbursement of litigation costs;

3. issue a check in the amount of $15,000 each to Betsy Duarte, Juan Duarte, Betty Nobles, and Leroy Nobles, as an incentive award.

IT IS SO ORDERED.

Dated this ___ day of __________, 2023.

____
HON. MICHAEL A. HAMMER
UNITED STATES MAGISTRATE JUDGE