



## Memorandum

*To: Chicago Department of Public Health*

*From: Richard R. Lester*

*Date: December 9, 2014*

*Subject: Impacts of Fugitive Dust Emissions on Soil Quality*

In consideration of KCBX's request for variance (2014), CDM Smith evaluated the presence of select metals and polycyclic aromatic hydrocarbons (PAHs) in petcoke and applied a simple model to estimate the deposition of these chemicals to soil in the vicinity of the facility due to fugitive dust emissions from KCBX's operations. The goal of CDM Smith's work was to determine whether soil sampling and analysis performed by Environmental Health & Engineering, Inc. (EH&E) for KCBX is a useful means of identifying impacts of atmospheric deposition of petcoke dust. The EH&E sampling and analysis was cited as a portion of the supporting documentation included with KCBX's request for variance.

Because the purpose of the modeling was to determine whether soil sampling and analysis could detect the presence of petcoke related contaminants in soil, CDM Smith was intentionally conservative when modeling the effects of fugitive dust emissions on soil quality. The modeling intentionally overestimates potential impacts to soil. For example, the modeling evaluates the deposition of petcoke-related contaminants to surface soil, but ignores deposition of the dominant constituent of petcoke – elemental carbon. If such conservative soil modeling indicates that contaminants would not likely be detected in soil samples, then it can be concluded with confidence that soil sampling and analysis under real world conditions would not be expected to detect petcoke-related contaminants.

Table 1 summarizes the presence of select chemicals in petcoke samples collected by CDM Smith on December 13, 2013 (on behalf of the City of Chicago) from KCBX's two bulk materials handling terminals (collectively, "The Facility") at 3259 East 100<sup>th</sup> Street (the North Terminal) and 10730 South Burley Avenue (the South Terminal). Only chemicals detected in at least one of the two samples are included in Table 1. Numerous additional chemicals that were not detected in either sample are excluded from the table. The right column of Table 1 provides the maximum concentration of each chemical detected in petcoke. CDM Smith used the maximum concentrations of chemicals in petcoke when modeling deposition due to emissions from the facility. This likely results in an overestimate of impacts to soil. Because the concentrations of contaminants detected in the two petcoke samples generally differed by a factor of two or less (with the exception of

manganese which differed by a factor of nearly seven), the resulting soil impacts will generally be overestimated by no more than a factor of two.

Ten chemicals were selected for further evaluation. These chemicals included three metals present in petcoke at elevated concentrations; aluminum, nickel, and vanadium; and seven PAHs – benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. CDM Smith estimated the rate at which the concentrations of these chemicals in surface soil could increase due to fugitive dust emissions from the facility, and also compared these rates of increase to background concentrations in soil.

CDM Smith used a simple model to estimate the rate of contaminant increase in soil due to the deposition of fugitive dust from the KCBX facility. The model used is that recommended by U.S. EPA (1994). EPA has since recommended a modified model including soil loss terms (U.S. EPA, 2005). The simplified model without the loss terms, however, results in an overestimate of impacts to soil. First the deposition rate ( $D_r$ ) of each contaminant was estimated:

$$D_r = C_{petcoke} C_{PM10} f_{petcoke} v_d M_{wetdry}$$

Where the terms are:

$D_r$	deposition rate of the contaminant (mg/m <sup>2</sup> -s);
$C_{petcoke}$	concentration of the contaminant in petcoke (kg/kg);
$C_{PM10}$	PM <sub>10</sub> concentration in air (0.050 mg/m <sup>3</sup> );
$f_{petcoke}$	fraction of PM <sub>10</sub> that is petcoke;
$v_d$	deposition velocity (m/s); and
$M_{wetdry}$	multiplier to account for both wet and dry deposition.

To estimate the rate at which contaminant concentrations could increase in soil, the following model was used<sup>1</sup>:

$$\Delta C = \frac{D_r}{z_s \rho_{soil}}$$

Where the additional terms are:

$\Delta C$	rate of concentration increase (mg/kg-s);
$z_s$	mixing depth (m); and
$\rho_{soil}$	bulk density of soil (kg/m <sup>3</sup> ).

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<sup>1</sup> This model also appears as Equation 5-1B in U.S. EPA (2005).

Table 2 summarizes the parameters used in the soil modeling. Parameter values are based on methods recommended in U.S. EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (2005), typical values, and professional judgment.

This model is a simplified approach to determine the potential impacts to soil. It includes several assumptions, such as the fraction of dust that is petcoke, that represent reasonable estimates of the true values, but which are not supported by robust data from the facility. Furthermore, the model likely overestimates potential impacts, because it assumes that the mass of contaminant due to facility emissions is added to the existing mass of soil, but does not account for the additional mass of dust added to the soil that is not contaminant. The true rate of increase for contaminant concentrations in soil would be less than those calculated herein. For example, the concentration of aluminum in petcoke is 390 mg/kg. It is assumed that 10% of the dust is petcoke.<sup>2</sup> The concentration of aluminum in the dust due solely to the presence of petcoke is therefore only 39 mg/kg. Additional aluminum could be present in the 90% of the dust that is not assumed to be petcoke, but this would be unrelated to the facility. Deposition of this dust to soil could never increase the aluminum concentration in soil due solely to the presence of petcoke in the dust given that the background concentration of aluminum in soil is 9,500 mg/kg.<sup>3</sup>

For contaminants other than aluminum in the analysis, the concentrations of the contaminants in petcoke are greater than the background concentrations of these contaminants in Chicago soil. For these contaminants, it is certainly possible that deposition of dust containing petcoke could increase the concentrations of these contaminants in soil in the vicinity of the KCBX facility. The true rates of concentration increase would be less than those estimated herein, but the estimates presented in Table 3 can be used as an indicator of the potential relative increase in soil concentrations due to deposition of dust containing petcoke from the KCBX facility.

Table 3 summarizes the results of the soil modeling, including potential deposition rates of the selected contaminants to soil (in units of mg/m<sup>2</sup> per year) and a potential rate of concentration increase in soil (in units of mg/kg per year). For comparison, the right two columns of Table 3 present the background concentration of each contaminant in Chicago soil (Illinois EPA, 2013) and the cumulative number of years it would take at the estimated rate of concentration increase to increase the concentration in soil by an amount equal to the background concentration (*i.e.*, to double the existing background level already present in soil). The number of years to increase concentrations by an amount equivalent to background concentrations ranges from a few decades to several centuries for vanadium, nickel, and the seven evaluated PAHs. The increase in aluminum

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<sup>2</sup> For the purpose of the evaluation, CDM Smith assumes by professional judgment that 10% of the PM<sub>10</sub> in the neighborhood is due to KCBX. If the actual contribution of KCBX is smaller than 10%, then the periods required to see discernable impacts in soil would be even longer than those estimated herein.

<sup>3</sup> Illinois TACO regulations (Illinois EPA, 2013), Appendix A, Tables G & H. The background concentrations of metals are assumed to be those for counties within metropolitan statistical areas. The background concentrations of PAHs are those for Chicago soil.

concentration would be negligible. For the reasons outlined above, the true rates of concentration increase would be less than those estimated in Table 3.

In summary, the goal of the soil modeling was to determine whether soil sampling and analysis would be expected to detect petcoke-related contaminants in surface soil. It is certainly possible that fugitive dust emissions from the KCBX facility contribute to contaminant concentrations in soil in the vicinity of the two terminals. However, the resulting increases in contaminant concentrations would generally be small in comparison to background concentrations of these contaminants. Consequently, due to the low modeled effect relative to background levels, using traditional bulk soil sampling methods to look for evidence of petcoke deposition at present or in the next few years is extremely unlikely to indicate that petcoke has been transported and deposited to off-site locations.

**Table 1 Concentrations of contaminants detected in petcoke**

Contaminant	South Terminal (mg/kg)	North Terminal (mg/kg)	Maximum (mg/kg)
<b>Petroleum Hydrocarbons</b>			
TPH (DRO)	56	34	56
TPH (ERO)	810	560	810
<b>Metals</b>			
Aluminum	390	190	390
Barium	11	6.8	11
Calcium	800	410	800
Iron	370	190	370
Magnesium	ND 130	190	190
Manganese	37	5.5	37
Nickel	58	71	71
Vanadium	200	260	260
Zinc	24	ND 20	24
<b>Polycyclic Aromatic Hydrocarbons</b>			
Anthracene	ND 3.6	4.8	4.8
Benz(a)anthracene	34	35	35
Benzo(a)pyrene	110	81	110
Benzo(b)fluoranthene	33	24	33
Benzo(g,h,i)perylene	160	100	160
Benzo(k)fluoranthene	13	9.1	13
Chrysene	68	66	68
Dibenz(a,h)anthracene	38	20	38
Fluoranthene	4.2	5.8	5.8
Indeno(1,2,3-cd)pyrene	22	20	22
Phenanthrene	7.6	11	11
Pyrene	46	55	55

ND indicates not detected and is followed by the detection limit.  
 The table includes only chemicals that were detected in at least one of the two samples.

**Table 2 Parameters used in the soil modeling**

Parameter Description	Symbol	Value	Units
PM <sub>10</sub> Concentration	$C_{PM10}$	0.050	mg/m <sup>3</sup>
Deposition velocity	$v_d$	0.01	m/s
Multiplier to account for both wet and dry deposition	$M_{wetdry}$	2	-
Fraction of PM10 that is petcoke	$f_{petcoke}$	0.1	-
Soil mixing zone depth for untilled soil (cm)	$z_s$	0.01	m
Soil bulk density	$\rho_{soil}$	1,500	kg/m <sup>3</sup>

**Table 3 Concentrations of selected metals and PAHs modeled in soil**

Contaminant	Maximum concentration in petcoke (mg/kg)	Deposition rate (mg/m <sup>2</sup> -yr)	Rate of concentration increase (mg/kg-yr)	Background concentration in Illinois soil (mg/kg)	Time to Double Background (yr)
<b>Metals</b>					
Aluminum	390	1.23E+00	8.20E-02	9500	1.16E+05
Nickel	71	2.24E-01	1.49E-02	18	1.21E+03
Vanadium	260	8.20E-01	5.47E-02	25.2	4.61E+02
<b>Polycyclic Aromatic Hydrocarbons</b>					
Benz(a)anthracene	35	1.10E-01	7.36E-03	1.1	1.49E+02
Benzo(a)pyrene	110	3.47E-01	2.31E-02	1.3	5.62E+01
Benzo(b)fluoranthene	33	1.04E-01	6.94E-03	1.5	2.16E+02
Benzo(k)fluoranthene	13	4.10E-02	2.73E-03	0.99	3.62E+02
Chrysene	68	2.14E-01	1.43E-02	1.2	8.39E+01
Dibenz(a,h)anthracene	38	1.20E-01	7.99E-03	0.20	2.50E+01
Indeno(1,2,3-cd)pyrene	22	6.94E-02	4.63E-03	0.86	1.86E+02

Notes:

Illinois background concentrations are from Appendix A, Tables G & H of the TACO regulations.

Metals background concentrations are for counties within metropolitan statistical areas.

PAH background concentrations are for Chicago.

## References

- Illinois EPA (2013). Title 35: Environmental Protection; Subtitle G: Waste Disposal; Chapter I: Pollution Control Board; Subchapter f: Risk Based Cleanup Objectives. Part 742 Tiered Approach to Corrective Action Objectives. Available at <http://www.ipcb.state.il.us/documents/dsweb/Get/Document-38408>.
- KCBX (2014). KCBX Terminals Company's Petition for Variance. June 9, 2014. ([http://www.cityofchicago.org/city/en/depts/cdph/supp\\_info/environmental\\_permitsandregulation/doe\\_ordinances\\_rulesandregulationsandsupportingdocuments.html](http://www.cityofchicago.org/city/en/depts/cdph/supp_info/environmental_permitsandregulation/doe_ordinances_rulesandregulationsandsupportingdocuments.html)).
- U.S. EPA (1994). *Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*. April 15, 1994.
- U.S. EPA (2005). *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. Office of Solid Waste and Emergency Response. September 2005. EPA530-R-05-006. Available at <http://www.epa.gov/osw/hazard/tsd/td/combust/risk.htm>.